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EDITORIAL NOTES

The Institution Meeting

FAVOURED by glorious weather, helped by increased membership, encouraged by a year of success and progress in a time of unparalleled international and national trade and industrial depression, the Institution of Gas Engineers, with customary atmosphere of cordiality and good fellowship, met in London last week for the Annual Conference, which, in many respects unique, was undoubtedly among the most successful ever held. It was unique in the place of meeting—the Park Lane Hotel, Piccadilly. There are, of course, pros and cons in regard to such an arrangement, but on the whole we think the general opinion was favourable. Admittedly traffic in the superlative was not conducive to hearty handshakes and prolonged conversations outside the meeting building. On the other hand, the holding of the business sessions and the social functions under one roof lent itself to ease of organization and smooth running, and punctuality of both technical sessions and social visits; and highly convenient were the amenities close at hand for informal conversation during the progress of the meeting.

The meeting was unique in that authors presented their papers in properly summarized form and in a few minutes only. The result was a series of discussions of remarkable value. The very fact that the authors themselves were concise had its influence upon the speakers, whose contributions were crisp and very much to the point. Again, at no meeting of the Institution have the subjects for discussion covered a wider field of the Gas Industry's activities. The tastes of all were met. The engineer of the large undertaking, the manager responsible for the prosperity of the small undertaking, the technician interested in power production on a large scale, the physicist, the industrial specialist, the statistician, the research worker, the administrator—there was general and technical fare for them all. And we doubt whether on any previous occasion such a high standard has been attained throughout the meeting either in the papers or the discussions.

The whole Industry has been benefited by the information which was placed at its disposal at this remarkable conference. In our Review to-day we present our readers with a running commentary of the entire meeting, singling out those items which impress us both in the contributions themselves and in the speeches and discussions; and it is unnecessary here to deal in any detail with the various items. In general, however, there can be no doubt that a change is coming over the Industry, and that its progress in all directions—the result of an enlightened policy of arriving at facts by paying closer attention to experimental methods and their rapid application—is being accelerated. It is obvious that new fields exist to be conquered, and that each year new developments show the enormous possibilities of gas in the home, in public service, and in industry. It is obvious, too, from the tone of the meeting that we are going to make a determined stand to retain and extend gas lighting. It can be done; and how it can be done is demonstrated by more than one paper. Also we stand on the threshold of astonishing industrial loads. There is the use of gas at high pressures for motor transport, made possible by the production of an alloy steel having astounding properties—light in weight and of high tensile strength and elasticity. For large-scale, moderate size, and small-scale heating appliances, gas—in face of competition from oil and solid fuel at the one end and electricity at the other—is, or at any rate can be made, a successful competitor. One of the speakers in the discussion mentioned that, as a result of a survey of his district, he has arrived at the conclusion that the body of industrial consumers are paying too much for their gas, and are supporting uneconomical consumers; another member spoke easily about the sale of gas to industry at 1½d. per therm. This is not bravado; it is a transformation. Again, we have been presented with working figures demonstrating that gas heating can be safely allied to low building construction costs. The builder now knows where he is. Then we have been shown new visions of policy in regard to both domestic and industrial sales. Small undertakings need have no qualms; determination and enthusiasm bring their own reward, as is clear from one of the papers.

Whatever the changes, however, there was the same whole-hearted welcome for the President, and throughout the meeting the cordiality and the spirit of enthusiasm to which we are accustomed. Mr. Canning worthily upheld the best traditions of presidential office, and there is no doubt that throughout his Presidential year he has more than maintained the prestige of the Institution both in our own country and in Canada and the United States. And once again Mr. Alexander, the Secretary, has given proof of his organizing capabilities.

Written Communications

ONE of the outstanding features of this meeting of the Institution promises to be the " written communication," which may in some cases prove of great value in elucidating points of importance to the Industry, and in others introduce a new form of terror for authors. For ourselves, meetings that terminate on " the appointed day " are sometimes embarrassing enough, and our task is hardly likely to be simplified if the discussions run on in writing for an indefinite period. On the other hand, the Industry wants all the useful information it can get, and written communications which add to the common store of knowledge will at all times receive consideration at our hands. Further, we will do what we can to present them in as convenient and as useful a form as possible.

Having said this, a moment's thought may be bestowed upon the author of the original paper. For some authors, at any rate, the contribution of a paper to the proceedings of a technical organization is an undertaking not lightly embarked upon. We can imagine an author of this kind—having submitted his paper; having stood up to be shot at, and having answered, or dodged, all the missiles, in the form of questions, which speakers in the discussion had hurled at him—leaving the platform

with a fervent " Thank goodness that is all over." He cannot so congratulate himself, with the " written communication " possibly lying in wait. For several weeks, perhaps, he must open his " JOURNAL " with a feeling of uneasiness as to what may confront him. In fairness it should be remarked that there is another aspect, even from the author's own point of view. One can visualize the dear old problem of the " herring-and-a-half " proving easier of solution in a written than in an oral explanation.

What has just been said, of course, is " in lighter vein," though the suggestion it contains is seriously put forward. We do feel that, though the written communication undoubtedly offers possibilities of great value, there are also advantages attaching to the " wiping up " of a paper during the business proceedings of a meeting—whether it be of the Institution or of any other technical body in the Industry. The life and sparkle of debate would be missing if the author merely sent his paper in to be printed, and then those who wished to discuss it sat at home and submitted written contributions. We have little fear of this happening, and should have still less if authors would keep better time in the preparation of their papers. Why is the sending in of a paper or an address so often a " last minute " job? It is a failing that should be corrected. With papers in the hands of members in ample time to permit of full study prior to the meeting, the need for the " written communication " would be minimized, or where they were necessary they could be read at the meeting at which the paper was presented, so as to form part of the discussion. If, even with this year's innovation—so long overdue—of reading short summaries only of the papers at the meeting, there is still insufficient time for discussion, a choice might be made of more sessions or fewer papers; and in either case speakers should have a time limit imposed upon them. But whatever else is done, or not done, the Secretary should undoubtedly be enabled to distribute prints of the papers to members desiring them in sufficiently good time for the contents to be thoroughly mastered before the meeting.

Reminiscent

A DELIGHTFUL informal function took place in the White Room at the Savoy Hotel, on the second evening of the meeting (Wednesday), when Mr. Charles F. Botley was enabled, by the courtesy of Mr. J. Herbert Canning, to entertain at dinner his colleagues and friends the Past-Presidents of the Institution of Gas Engineers. It was a memorable evening, affording to those present an opportunity—all too rare in these days, when the present and the future are so insistent—of living once again for a short time in the past. There was brought back to mind that episode of many years ago—the " split," when there were both a Gas Institute and an Incorporated Institution of Gas Engineers—and also the subsequent merging again of these two organizations into one big one. Of the Past-Presidents of these bodies there are—including Mr. Canning, as we may do now—happily no fewer than twenty-three still living, and it will be interesting to name them here, with their years of office: Dr. Charles Carpenter (1895); Mr. Frederick D. Marshall (1899), Mr. W. Ralph Herring (1901); Mr. Charles Wood (1906); Mr. W. Doig Gibb (1908); Mr. Thomas Glover (1909); Mr. R. G. Shadbolt (1912); Mr. John Bond (1915); Mr. John Young (1916); Mr. A. E. Broadberry (1917); Sir Dugald Clerk, K.B.E., D.Sc., F.R.S. (1920); Mr. Thomas Goulden (1921); Mr. Thomas Hardie (1922); Mr. James D. Smith (1923); Mr. Samuel Tagg (1924); Sir John Ferguson Bell (1925); Mr. Charles F. Botley (1926, the year in which the meeting was postponed until September, in consequence of the coal strike); Mr. John Wilkinson (1927); Mr. H. D. Madden (1928); Mr. John Terrace (1929); Mr. C. S. Shapley (1930); Mr. Harold E. Copp (1931); and Mr. J. H. Canning, who when he sat down to dinner had still a few hours more of office before him (1932). Eighteen of these gentlemen were present, while the remaining five (Mr. Wood, Mr. Broadberry, Sir Dugald Clerk, Mr. Goulden, and Sir John F. Bell) sent greetings. Death has unhappily removed a number of Past-Presidents—well-known men, who made their mark. The most recent of these were Mr. Samuel Glover (1919), the Right Hon. Lord Moulton, K.C.B., F.R.S. (1918), Edward Allen (1914), and Sir Corbet Woodall (1913).

How great a part of the history of the Gas Industry during the past half-century and more do the names mentioned above recall! How closely connected have these leaders been with the marvellous growth of an essential public service! During the dinner, Mr. Botley himself reminded us that in 1895—Dr. Carpenter's year of office—the quantity of gas sold was 111,000 million c.ft., and that there were in round figures 2,600,000 consumers. Pass from this to Mr. Canning's Presidency—a span of less than forty years—and Mr. Botley estimates that the amount of gas sold will be found to be something like 300,000 million c.ft., and the number of consumers about 10,000,000. As he remarked, " a stupendous achievement," in which those present can claim a very substantial share. Each Past-President in turn was invited to recount the main features of his period of office; and memories were revived of what, looking behind us, seems almost to have been a different life. Yet how closely is it all bound up with the present! These memories are events which have led up to—nay, created—the present greatness of our Industry. Truly, the recital made us all realize the wisdom of a remark made by Dr. Carpenter at the opening—" How much we owe to other people, and how little to ourselves."

Did the philosopher once say, " Happy is the country that has no history? " Such a thought has no application to the Institution of Gas Engineers or to the Gas Industry. Both have a great tradition—a past that will be of inestimable value in the future. We offer to you, Mr. Botley, gratitude in full measure and overflowing for the kindly thought, translated into charming action, which took us back for one delightful evening to the days that are gone. To quote Dr. Carpenter once again, " the particular characteristic of hospitality which we found in Mr. Botley's father has descended to the son."

Led in the future as they have been in the past, the Industry and the Institution will go on to further triumphs, though not to greater honour.

OBITUARY

We regret extremely to learn of the death, on June 7, of Mr. HARRY OSWALD CARR, M.Inst.C.E. He was 59 years of age, and had for some time past suffered from ill-health. Mr. Carr was for many years Engineer to the Wandsworth, Wimbledon, and Epsom District Gas Company, until a breakdown in health compelled him to retire in 1919. In the year 1913 he was President of the Southern Association of Gas Engineers and Managers.

The death took place, on June 8, of Mr. H. LUGSDIN, after a very short illness. Deceased served the firm of Messrs. William Sugg & Co., Ltd., in the capacity of Photometrician and Technical Expert for over thirty years, and was held in very high regard by all, including many gas engineers in various parts of the country. By his untimely death the Company has lost a very valuable and loyal servant, whose place it will be hard to fill.

The death is announced at Lytham of Mrs. RHODES, widow of Mr. William Rhodes, for a long period an official of the Accrington District Gas Board. Mrs. Rhodes for many years carried on a successful business in Blackburn Road, Accrington.

Mr. ROLAND PEARCE, the Davis Gas Stove Company's representative in the home counties and East Anglia, passed peacefully away on Friday, June 3, after an illness of a few months, aged 42. He leaves a widow and a young son.

Manchester District Association.—The next Meeting of the Manchester District Association of Gas Engineers will be held on Friday, July 1, when members will have the opportunity of visiting the President's Works at Wakefield. The Chairman and Directors of the Wakefield Gas Light Company have invited the members to luncheon, after which the dry coal-cleaning plant at Messrs. Terry, Greaves, & Co., Roundwood Colliery, will be inspected.

THE "JOURNAL" REVIEW

Of the Institution Meeting

June 7, 8, and 9

Years ring the changes, we are told. Well, 1932 rang one change as far as the Institution of Gas Engineers is concerned. Almost a meeting "Americanized," we thought, as we stepped down into the gilded ballroom of the Park Lane Hotel, Piccadilly. A custom at these annual gatherings of the Institution is that participants in memorable meetings should stand outside any meeting building until 10 a.m. prompt. Did Piccadilly outrage Tradition? The answer to this rhetorical question is, Partially, not quite; for the police constables of London—on the Tuesday morning—had loving hearts. And, after all, the handshakes of gas engineers in the early part of June are not lightly to be overridden by traffic in the superlative. However, on the Wednesday the President had to ask members to "move on" when they were in Piccadilly. There was a change, then, at this, the 69th Annual Meeting of the Institution of Gas Engineers. But, as far as concerned the meeting proper, the change was superficial. There was the same wholehearted welcome for the President. Above all, and surrounding all (for the galleries of the ballroom were filled to overflowing), there was the same spirited enthusiasm. We could talk about the golden field of chairs, and about a host of other incidentals—but the meeting is in full swing.

An alert Secretary—Mr. Willis Alexander—is on his feet, reading the notice convening the meeting. Followed the President's hearty greetings and cordial welcome, and his explanation of an overdue innovation—the arrangements which had been made to secure the maximum of time for the discussion of papers. This year the authors of papers presented them in properly summarized form, with consequent gain in the value of the proceedings at the meeting.

Then Mr. Canning welcomed Overseas Representatives: Hermann Müller, Director of Gas-Works, Hamburg, Immediate Past-President of the German Association of Gas and Water Engineers; John Irminger, Chief Engineer and General Manager, Gas-Works, Bergen, Past-President Norwegian Gas-Works Association, representing the Association; Sigurd Samzelius, Managing Engineer, Gas-Works, Göteborg, representing the Swedish Gas-Works Association; Henri Gunst, Director, A/s Nordiske Auer Kompagni, Copenhagen, representing the Danish Gas-Works Association; and Viggo Arnold, representing Johs. E. Borresen, Engineer to the Copenhagen Lighting Department. At the invitation of the President, the Overseas Representatives occupied seats on the platform.

The Secretary informed the meeting of the receipt of a telegram from Mr. Clifford E. Paige, President of the American Gas Association, expressing good wishes for the success of the conference; and of an invitation from the French Gas Association to their Annual Congress in Paris, June 14-18. Messages of good wishes had also been received from the Hungarian Gas Association and the Swiss Gas and Water Association.

Bricks and Mortar.

We then commenced the business of the meeting, when the President moved that the Annual Report for 1931-32 be taken as read and adopted—a motion which met with no comment. The Report shows a satisfactory increase in the Institution membership, which at the end of last December totalled 1467—an increase of twenty-three. And, of course, those admitted to membership during the past six months will swell the total considerably. Most of the Report is a résumé of what took place at the meetings in June and November last year. One or two items, however, appeal for comment. In particular our readers will be glad that a Building Committee has been appointed to be responsible to the Council for the housing of the Institution and to report without delay upon any available site or building suitable for accommodation of the Institution. For years this matter has been discussed and better discussed, and it is to be honed that at long last the importance of the Institution will find expression in bricks and mortar (or steel and concrete). Then reference is made to the inauguration of a Gas Museum, though limited accommodation precludes the exhibit of large gasholders or full-scale coke oven installations. On quite another matter, it is noteworthy that the regulations of the Institution Education Scheme are being revised, and that there has been gratifying increase in the number of students and examination candidates. As before, the Report of the Gas Education Committee will be presented at the Autumn Research Meeting, so that it will cover a complete educational year.

Another pleasing feature of the Report is the increasing co-operation between the Institution and other Central Gas Organizations, and closer contact with other engineering, technical, and professional bodies, and with Gas Associations overseas.

At this stage Mr. T. W. Harper and Mr. A. Gregory were appointed scrutineers of the ballot for the election of officers, auditors, and council and members of the Institution.

Presentation of Medals.

Mr. J. Stanley Thorman was then asked by the President to step up to the platform to receive the Institution Gold Medal for 1931, for his paper on Intermittent Vertical Chambers and Coal and Coke Handling Plant at Southall, which was read on June 2, 1931. That the choice is popular was evidenced by the applause when Mr. Thorman was presented with the Medal. In a brief speech the recipient thanked those who had made possible the preparation and presentation of the paper.

The Henry E. Jones London Medal, 1931, was awarded to Mr. Alfred L. Holton for his contribution on the Semi-Direct Recovery of Ammonia in Gas-Works Practice and the Recovery of Tar Acids from Ammoniacal Liquor, also read on June 2 of last year. It will be remembered that at the 1931 meeting of the Institution Mr. Holton was presented with the Silver Medal of the Institution; and we think that these successive awards to the same member of the Institution constitute a unique happening. Mr. Holton, having expressed his appreciation of the honour conferred not only upon himself but also upon the undertaking he serves, said that his gratification is greater to-day because the process he described in the paper had worked now for the past twelve months fully satisfying all his anticipations.

Two more presentations: The Institution Silver Medal, 1931, was awarded to Mr. Walter Grogono for his paper on Intermittent Vertical Chambers at Croydon, read at the meeting of the Southern Association of Gas Engineers and Managers in November of last year—a paper which the author described as the work of a team of whom he was extremely fortunate to be Captain. The final award was the Institution Bronze Medal, 1931, to Mr. E. W. B. Dunning, of the staff of the Gas Light and Coke Company, for his paper on Incomplete Combustion, before the London and Southern District Junior Gas Association in January last.

To Meet in the Provinces.

On behalf of the Chairman and Directors of the Liverpool Gas Company, Dr. Clayton, M.P., a Director of the Company, extended to the Institution an invitation to hold their next annual general meeting in Liverpool—an invitation which was accepted by the meeting amid applause. The dates fixed are May 30 to June 2, 1933.

A Sheet Anchor.

The President then rose to deliver his Presidential Address, which was listened to with obviously keen and appreciative interest. Characterized by dignified charm, the Address shows that high hopes regarding the future of the Gas Industry are thoroughly justified. In a time of unparalleled international and national industrial and economic troubles, our Industry at least has proved a sheet anchor of the greatest stability. During the last twelve months (we quote Mr. Canning) "the financial security of many other countries has trembled in the balance, great financial interests have foundered in the storm, and far too many of our staple industries have, wholly or partially, lost

their profit-earning capacity." Yet the Gas Industry " has not only survived this unexampled economic tempest and trade depression, but has fully upheld its position, and, even at a moment when Government securities were severely affected by world-wide uncertainty and apprehension, the stocks and shares of gas companies maintained their value in a manner unsurpassed by the securities of any other trade or industry."

We regard as a happy augury for the future the increasing co-operation between the Gas Industry of Great Britain and that of Continental countries and of America—a new era which was heralded at the International Gas Conference last June. Since then Mr. Canning has visited, in the capacity of President of the Institution, both Canada and the United States; and his impressions of the spirit of international friendship and of the benefits of wider technical discussion are recorded in his Address, in which he quite naturally remarks on the progress of gas in the two " electrical " countries he visited. There is every reason for satisfaction in his remarks. In Toronto, for example, which is supplied with electrical energy generated at Niagara, the rates for electricity for household use are probably lower than in any other comparable community elsewhere. Notwithstanding this, the Consumers Gas Company of Toronto has a remarkable record of continuous progress and prosperity. In the last ten years the total sales of gas have increased by more than one-third. And a similar story is to be told of the progress of manufactured gas in the United States of America. These results have been achieved by engineering skill, business acumen, and vigour and enthusiasm; but there can be little doubt that the absence of antiquated legislation has helped enormously in this development. And Mr. Canning looks forward to the freeing of the Gas Industry of our own country from the legislation and municipal obstruction which weigh so heavily and so unfairly against the Industry.

On the work of the Institution of Gas Engineers, Mr. Canning refers particularly to the increasing value of the research work annually carried out in co-operation with the University of Leeds, to the welcome development of the co-operation of the Institution with the research departments of the larger gas undertakings and of private laboratories, and to educational work. The labours of the Education Committee are bearing fruit, as is demonstrated by the fact that the number of entrants for the Examinations of the Institution this year showed an increase of over 56 p.ct. as compared with last year. " It may now be confidently stated," observes Mr. Canning, " that, on the lines laid down, an intelligent and industrious aspirant will attain a standard both of general and specialized education which will admirably fit him for the tasks which await him in the future. It is vital, however, that the right type of candidate should present himself, and the responsibility for securing this, which does not rest with the Institution, is a very real and serious one, as our future success depends upon the maintenance of the proper standard." If the prospective rewards of a Gas Engineering career are sufficient, the right type of candidate will not be lacking. In the case of most undertakings this is fully realized and acted upon, but we are in complete agreement with the President that, until such action becomes universal, the full possibilities of the Industry will not be developed.

" A First-Class President."

The thanks of the members to the President for his Address were voiced by Mr. H. D. Madden, who remarked that Mr. Canning's year of office had shown him to be a first-class President. During his tenure the Institution has progressed in strength and in research and scientific activities.

The vote of thanks was seconded by Mr. P. S. Hoyte, who was in reminiscent vein. " Forty years have elapsed since I first attended an Institution meeting," he observed, " and for the first time heard a Presidential Address; and while listening to our President to-day I could not help thinking how very oddly the headings of his Address would have fallen from the lips of a President forty years ago. Central heating by gas; restriction of the use of gas in council houses; road reinstatement owing to heavy motor traffic; the Coal Mines Act; flood lighting by gas; research work (including liquor effluents), and so on. These were matters which were not even dreamed of forty years ago, and they indicate the extraordinary progress which has been made and the complexity of the problems the Institution now has to face." Mr. Hoyte also spoke in high terms of the standard of education of the new recruits to the Industry.

Economy in Power.

Priority of place in opening the technical business of the meeting was allotted to Mr. F. M. Birks, of the Gas Light and Coke Company, who presented a paper on the " Co-ordination of Power Relative to Gas-Works," in which he examines the general principles underlying the various applications of power required at a gas-works, describes particular uses, and suggests the most suitable forms of power. His contribution is a masterly treatise on a subject with which, as a result of exceptional experience, he is so admirably fitted to deal.

The generation of steam in fuel fired and in waste-heat boilers is discussed, and the direct use of steam in process work and generation of power is considered. The advantages of the reciprocating engine and the turbine are contrasted, and the author explains that, where what may be termed bye-product steam is not available at low cost, gas engines have certain advantages. The use of compressed air, hydraulic power, and steam as a means of transmitting power is dealt with, and a section of the paper is devoted to the various applications for which electricity is considered suitable. Included is a description of the application of power in four works of the Gas Light and Coke Company.

The paper is full of sound advice and will prove a source of valuable reference to anyone contemplating either new power plant or the modification of existing systems. The contribution gives an idea of the influence of power costs on the total costs of gas production and of the great advances in both production and utilization which have been made during recent years. As a matter of fact, little is said about the use of gas engines as prime movers, though emphasis is laid on their advantages in isolated situations. They are more reliable than electric motors taking current from an outside source, and are very useful for stand-by electrical generating plant. Liability to failure is the disadvantage of electricity, but its numerous advantages render it supreme for many classes of work, and it is being employed more and more in gas-works. Its chief advantage, perhaps, is its ease of control, so that complicated sequences of plant operation can be performed by attendants without fear of error. For the production of electrical energy the steam driven prime mover has many points in its favour, particularly in gas-works, where the necessary supply of steam can be produced at low cost, either from surplus heat from the retort settings or from low-grade cheap fuel—breeze.

Harnessing Surplus Heat.

On the matter of waste-heat boilers for the generation of steam Mr. Birks has much to say which is new, and his conclusions regarding the complete equipment of such installations—feed water pumps, fans, superheaters, and so on—are of the utmost importance. The author offers the useful suggestion that there should be a standard method of rating this class of boiler, for at present comparison of the heating surfaces of boilers of different makes may be misleading. Even when the whole or the greater part of the steam required is raised by waste heat, the point is made that direct fired boilers are still necessary; and in this connection the author's description of a new type of furnace which will burn coke breeze efficiently is extremely interesting. Actually, the particular installation dealt with by Mr. Birks and incorporating this new furnace produces steam at 1s. 9d. per ton and electricity at ½d. a unit. Almost the whole of the power used in the works of the Gas Light and Coke Company is now produced by steam either direct or by conversion into electrical energy. The annual production of electricity by the Company is nearly 15 million units, and 68 p.ct. of steam is raised by waste heat. Mr. Birks states that for the generation of electricity the high-speed compound reciprocating engine is most economical for powers below 250 kilowatts, but for powers in excess of this the turbine is now generally used. He summarizes the methods adopted to increase economy in the generation and use of power as: The use of waste heat and low-grade fuel for the raising of steam; the combined use of power and process work by employing back-pressure or pass-out turbines; the adoption of the most efficient form of prime movers where the direct use of steam is essential; and the extended use of electrical transmission.

Concluding his paper the author presents an enlightening analysis of the relative economies of waste-heat boilers and regenerators in reference to the new coke oven installation opened by the Prince of Wales at Beckton last month. These ovens are fitted with reversing air and waste gas regenerators which are so efficient that the waste gas leaves the outlet of the regenerators at a temperature of 250° C., which is approximately the same temperature at which the waste gases are discharged to the chimneys from horizontal retort settings at the same works after passing through a simple recuperator and waste-heat boiler. In this particular instance, leaving out of consideration capital costs, labour charges, &c., the coke oven installation shows a substantial financial saving in fuel by generating steam in boilers direct fired by breeze. This example shows clearly the need for studying closely the power costs in relation to

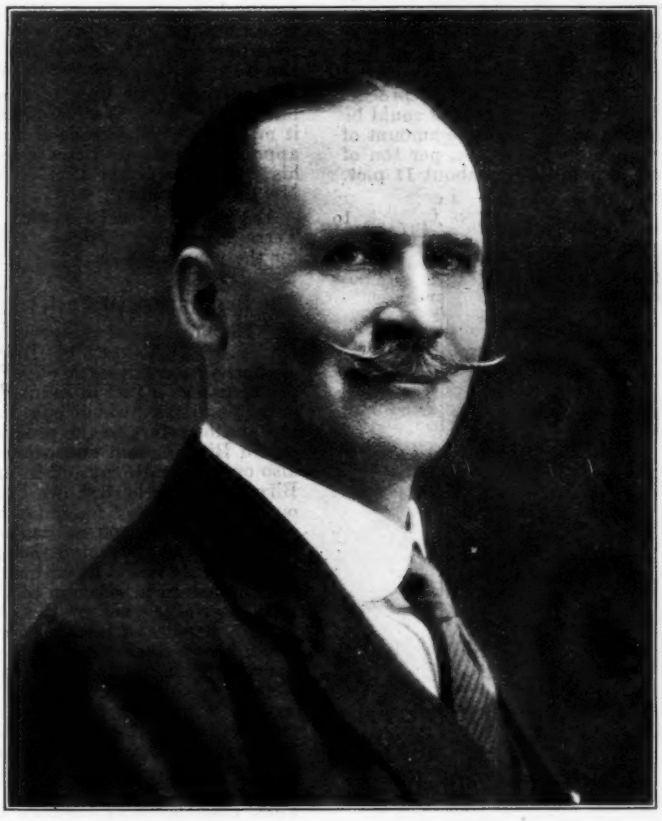
local conditions. The entire paper is, in fact, evidence that the subject is not stereotyped, and it is certainly proof that it is of great importance.

Self-Supporting Generating Stations.

The discussion which followed the presentation of Mr. Birks's paper was a forerunner of a series of full and valuable discussions which, perhaps more than anything else, characterized this memorable meeting. Once again, remarked the President, inviting Alderman F. J. West to set the ball rolling, the Institution is under a debt of gratitude to the Gas Light and Coke Company and to their Chief Engineer for the permission given to Mr. Birks to publish invaluable information for the benefit of the Institution and for the Gas Industry as a whole. Alderman West emphasized that the gas engineer, for the successful solution of his many problems, requires a range of technical and practical knowledge wider than is perhaps required in any other branch of engineering. The outstanding feature of the paper, he pointed out, is the extraordinary extent to which waste heat is used in the gas-works of to-day for the production of cheap power; and another outstanding development is the extended use of electrical transmission. In this regard prejudice against the use of electricity is fast disappearing; gas-works have, indeed, become almost entirely self-supporting in the generation of their own current.

The question of dry coke quenching was, among other matters, discussed by Dr. E. W. Smith, who mentioned that many gas engineers and many contractors have given, and are giving, careful consideration to the possibilities of utilizing for steam raising the heat in the hot coke as discharged; but the author had shown that on one particular works at any rate—he referred to Brentford—dry coke quenching for this purpose is not attractive because of the high capital costs of the installation. Having mentioned some of the advantages which accrue from the use of superheated steam in transmission about the works, the speaker offered the suggestion that if gas is charged for power purposes—or, for that matter, for other purposes where there is a constant outlet on the works—at a very low cost (a cost lower than for industrial supply), the employment of gas engines may well be justified, just as benzole extraction is justified. The importance of metering boiler feed water was stressed by Mr. Madden, who cited as an example the saving of £800 a year in the water bill at his works by isolating every boiler house and installing a meter in each case.

A valuable contribution to the discussion was made by Major W. Gregson, who, among many other matters, referred to the use of steam and electricity for driving induced draught fans. Though he agrees with Mr. Birks up to a point—that if there is likelihood of interruption of electric supply, then the steam-driven fan offers greater advantages—he thinks that the electric drive has much to commend it on the score of both simplicity and economy; and nowadays the risk of shut-down by electrical failure is "extremely remote." On the subject of the relative economies of waste-heat boilers and regenerators, Major Gregson said that every hot producer gas fired type of setting affords a case for waste-heat recovery, and every coke oven plant fired by



J. HERBERT CANNING, O.B.E.,

Engineer and Manager of the Newport (Mon.) Gas Company.

Mr. J. Herbert Canning has been Engineer and Manager of the Newport (Monmouthshire) Gas Company since 1919, being the eldest son of the late Mr. Thomas Canning, who was Engineer and Manager of the same works for many years before him until his death in 1919. Mr. J. H. Canning was educated at Prior Park College, Bath, and subsequently studied engineering and science at the Technical College, Newport, where he was particularly successful. He was Silver Medallist in science in 1893 and Gold Medallist for the best record in science over the three years 1892 to 1895. In 1897 he was successful in gaining the first prize in the honours class, and the National Silver Medal awarded in connection with the examinations of the City and Guilds of London Institute. He has twice been President of the Wales and Monmouthshire Association of Gas Engineers and Managers—in 1910 and 1920—and it is of interest to note that his father was the first President of that Association. In 1915 he was appointed by the High Explosives Committee to organize and direct the work of providing high explosives in Wales and Monmouthshire, and was assisted by a committee of five gas engineers. He was appointed Divisional Officer (coke and gas) for the same area in 1918. He was made an Officer of the Order of the British Empire in 1920 for war services. Mr. Canning is Chairman of the South Wales District Committee of the Federation of Gas Employers and also of the South Wales Regional Gas Industrial Council.

coke oven gas or clean, cold, producer gas allows for full recuperation by regenerators alone.

Dry Cooling of Coke.

A plea for the dry cooling of coke was put in by Mr. L. H. Sensicle. In his opinion the author is hardly fair in dismissing the matter so shortly. "If," said Mr. Sensicle, "one considers that the heat discharged in the red hot coke amounts to at least half the amount of heat consumed in carbonizing the coal, one can see that the matter is of some importance, to say the least." Fire-brigade methods of coal quenching do not appeal to Mr. Sensicle. To his mind the ideal system of carbonizing plant comprises reversible regeneration and the raising of waste-heat steam, not from hot gases from the combustion flues, but from the heat of the coke.

Mr. E. B. Tomlinson asked the author several questions, among which was the efficiency of dust arresting devices; and he expressed complete agreement with Mr. Birks in the use of steam for driving fans of waste-heat boilers. Quite an exhaustive analysis of power production on gas-works was submitted by Dr. G. W. Anderson, who remarked that dry coke cooling is not a paying proposition on gas-works when other methods are available, but that the picture assumes a different aspect when there is a profitable outlet for the steam either for power production or for process work. Taking into consideration the steam which could be generated cheaply from coke breeze, the average amount of available steam on gas-works is about 1570 lbs. per ton of coal, so that electrical energy amounting to about 17 p.ct.

F. M. BIRKS, O.B.E., M.I.Mech.E.

Mr. Birks was for many years engaged in Harbour Engineering at Swansea, and was responsible for the installation of the mechanical equipment of the King's Dock, completed in 1909. He was Chief Assistant Engineer from 1911 onwards. He joined the Gas Light and Coke Company as Mechanical Engineer at their Beckton Works in 1921, and was transferred to Horseferry Road as Mechanical Engineer to the Company in 1929.

of the total amount of electricity generated could be produced by the Gas Industry annually—an outlet which is, however, now closed to the Gas Industry. "However," concluded Dr. Anderson, "the signs of the times point to the possibilities of a greater development of chemical activities on the part of the Gas Industry, which has a singular opportunity of utilizing its resources in this direction. As power is an item of inestimable value among these, it is hoped that the potentialities will not be ignored."

Pro Tem.

In his verbal reply—a written reply is promised—Mr. Birks explained that at Brentford no space is available for dry quenching of coke, and expressed regret if he had given the impression that he does not consider dry quenching suitable; but the point has to be borne in mind that a dry quenching boiler does not eliminate other boilers. Commenting on Mr. Madden's remarks, he mentioned that his Company makes every effort to utilize condensed steam, and that every boiler used is fitted with meters for the feed water, and wherever possible for the fuel. Direct fuel fired boilers are recommended entirely on the score of reliability. Answering Major Gregson, Mr. Birks observed that, though on the face of it electrically driven fans are cheap, if the capital cost involved in the cables and in the share of the stand-by machinery of the generating plant, as well as in the generating plant itself, is taken into consideration, the total cost may be higher with electrical transmission than it is with steam. The coke oven installation at Beckton definitely shows that regeneration is of a very high order and that the fuel is actually saved. It is not merely a saving on paper. As for dust arresting apparatus, all forms are more or less efficient.

Benevolent Fund Progress.

Prior to the General Meeting on Tuesday afternoon, a meeting of contributors to the Benevolent Fund of the Institution took place. This is reported *in extenso* in later pages of our issue to-day. The President mentioned that the accounts show a progressive increase in the subscriptions to the Fund and in the number of contributors; but much more remains to be done. Mr. Canning also announced, amid applause, Mr. Frank H. Jones's fourth contribution of £100 which he had made that day, and a contribution from Dr. Hermann Müller, a Past-President of the German Gas and Water Association.

There was little discussion on the Report and Accounts, but Mr. H. R. S. Williams put forward the suggestion that it might be a good thing if a member for each county were appointed to try to increase the membership of the Fund in his county—a suggestion which met with the support of Mr. C. S. Shapley.

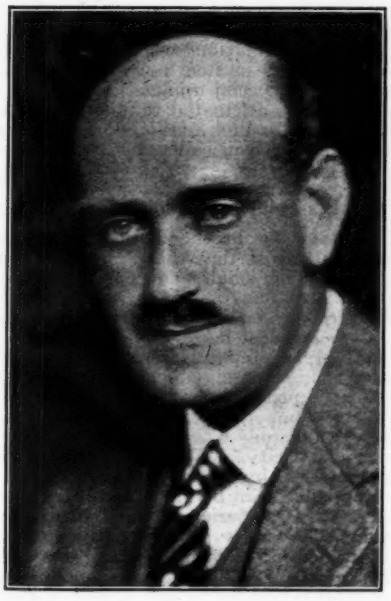
As a result of the ballot, Mr. A. L. Jennings and Mr. John Terrace were elected to the Committee of Management for the years 1932-35.

The Best Industrial Fuel.

The business of the general meeting was then resumed, Dr. C. M. Walter, of Birmingham, an acknowledged authority, presenting a paper on the vital question of the use of gas as a fuel in industry. In an introduction to his valuable paper, which contains so much original matter, the author refers to the progress of gas for industrial heating in Birmingham and other centres in this country, and also on the Continent and in America. The development in Birmingham is best shown by the fact that the increase in output of gas used for industrial purposes alone since 1913 is no less than 2600 million c.ft.—an increase of over 500 p.ct. Having reiterated the special advantages of gas, Dr. Walter deals in detail with thermo-dynamic considerations of combustion in relation to waste heat recovery, and submits several curves of the thermal properties of various gases. Results of tests on a carbonizing furnace are given and a heat balance is worked out from the results obtained. A table of gas consumptions for large-scale industrial operations is set out and figures of gas consumption included in descriptions of the more important general applications of gas in industry, covering forging, case hardening, reheating, metal melting, japanning and drying operations, food production, and central heating. With some of the more recently designed central heating apparatus now available, efficiencies as high as 80 p.ct. can be realized, and where town gas can be obtained at a cost approximating 4d. per therm, it is generally found that this form of fuel can compare favourably with other fuels.

The first section concludes with a brief discussion on the economic value of town gas as an industrial fuel in relation to its competitors. Speaking of coke oven gas, Dr. Walter observes that at present, as far as this country is concerned, such gas is only available in the vicinity of some of the principal coal producing districts, where, in many instances, solid fuel can be procured at figures as low as 0·5d. per therm, including service costs. In many of the manufacturing operations carried out in these districts, it is not necessary for the furnace plant to be operated within very fine limits of temperature control; further, it is not always essential that the fuel should be free from impurities. In such cases the economic value of coke oven gas would be from 2 to 2½ times the cost of solid fuel; and, for these particular operations, where unpurified coke oven gas can be supplied at prices round about 1½d. per therm, its employment would be fully justified in place of solid fuel. In regard to processes where temperatures must be maintained within close limits and where furnace atmospheres must be under complete control and free from contaminating impurities, the economic value would be, in the special circumstances referred to, 3 to 5 times the cost of coal. With purified coke oven gas for many special heat-treatment operations demanding conditions as mentioned, a cost of 2d. to 3d. per therm would be easily justified. From general experience, the author concludes that if gas undertakings supplying large industrial consumers are able to

THE 1931 MEDALLISTS



J. S. THORMAN.

Mr. J. S. Thorman served for 15 years in the West Ham Gas Company, and in 1910, when this Company was amalgamated with the Gas Light and Coke Company, he was transferred to Beckton as Assistant Engineer. He was appointed Deputy Resident Engineer at Beckton in 1916, Engineer at Bow Common in 1920, and Stratford in 1921, a position he held for five years. He was appointed to Southall as Engineer in 1926.

ALFRED L. HOLTON.

Mr. Alfred L. Holton is a native of Sheffield, and commenced his career in the Industry in 1890 under Mr. Fletcher W. Stevenson, Engineer of the Sheffield United Gas Light Company. Commencing in the laboratory, he served in various capacities at each of their three works. During his term of service, the Grimesthorpe Gas-Works were erected and put to work, Mr. Holton being appointed Works Chemist and Manager of the Bye-Products Works in 1899. His next appointment was that of Manager of the Bye-Products Works of the Manchester Corporation in 1902, becoming Works Superintendent at the Bradford Road Gas-Works in 1914. From 1916 to 1922, the whole of the Bradford Road Gas-Works were entirely reconstructed and extended into a works capable of producing 23 million c.ft. per diem, and on completion Mr. Holton was appointed Manager. He was appointed to his present position of Chief Engineer to the Manchester Gas Department in 1928. Mr. Holton has always taken a very keen interest in the various professional associations connected with the Industry, and he inaugurated the Joint Junior Gas Associations' activities. He was the President of the Manchester and District Junior Gas Association in 1911. Last year he was the recipient of the Institution Silver Medal.

W. GROGONO.

Educated at Epsom College, Mr. Grogono became a pupil of the late Mr. John Clark, of the West Ham Gas Company, in 1904. He was appointed an Assistant Engineer to the Gas Light and Coke Company when they amalgamated with the West Ham Gas Company in 1910, and served in that capacity at Stratford, Beckton, Bromley, and Fulham. In 1927 he was appointed Engineer to the Croydon Gas Company, the post he now fills. Mr. Grogono was President of the London Junior Gas Association in 1924.

E. W. B. DUNNING, B.Sc., A.I.C.

Mr. Dunning was educated at William Ellis School, Gospel Oak. He entered the Gas Light and Coke Company's service in January, 1926, and was transferred to Watson House on its inception in June of the same year. He studied at Birkbeck College, University of London, during the years 1926-29, and obtained a B.Sc. Degree (2nd Class Honours in Chemistry). Mr. Dunning is Lecturer in Gas Laboratory Practice at the Westminster Technical Institute.

offer gas at 4d. a therm, a large field lies open for the development of new business.

Gas for Motor Transport.

Perhaps the most fascinating portion of the paper is Dr. Walter's outline of the present position of the application of town gas to high-speed internal combustion engines, and his detailed results of experiments carried out by the City of Birmingham Gas Department on standard engines. Costs of compressing gas to 200 atmospheres with both electrically and steam driven plant are given, with particulars of the type of compressor necessary.

The conclusions derived from the tests may be summarized as follows: The thermal efficiency of high-speed internal combustion engines when supercharged is greater when using town gas than when petrol is used, and is further increased by carburetting the gas with benzole; the thermal efficiency with petrol as a fuel is decreased by the application of supercharging; the maximum power developed with gas alone is lower than that obtained with petrol; the CO content of the exhaust gases is considerably less with town gas as a fuel than with petrol; gas is more responsive to supercharging than petrol, the power output being increased to a greater extent; the thermal efficiency obtained with town gas would be further improved by increasing the compression ratio: and the performance of the engine is very much improved by saturating the gas with benzine or benzole, the amount of benzine required being about ¾ of a gallon per 1000 c.ft. of gas. With a standard type of engine having a compression ratio of 5 to 1, one gallon of petrol would give about the same performance under average conditions of running as 265 c.ft. of gas of 475 B.Th.U. per c.ft., this figure being reduced as the compression ratio is increased. With gas carburetted with benzole, this figure would be reduced to about 200 c.ft., the carburetted gas having a calorific value of approximately 575 B.Th.U. per c.ft.

DR. C. M. WALTER.

Dr. Walter was educated at King Edward's High School, Birmingham, where he obtained a Foundation Scholarship, and, later on, entered on an engineering course at the Birmingham University. There he spent four years on Civil, Electrical, and Mechanical Engineering, and also several courses in Accountancy. He obtained a degree of B.Sc. in Mechanical Engineering, and subsequently the degree of D.Sc. in Engineering in July, 1919. On leaving the University, he joined the City of Birmingham Gas Department in 1909, where he was engaged in connection with the development of the use of gas for industrial purposes. In 1910 it was decided to establish a special laboratory to deal with the development of gas industrially, and Mr. E. W. Smith (now Dr. E. W. Smith) was appointed in charge of this laboratory. Dr. Walter continued development work as Chief Assistant until 1912, when he was made Superintendent, on the appointment of Dr. Smith as Chief Chemist, of the Birmingham Gas Department. In October, 1916, the Birmingham City Council approved the establishment of an Industrial Research Laboratory, which resulted in the existing laboratories for the development of gas industrially being considerably extended to cover general testing of all kinds, including heat-treatment work, and mechanical, physical, chemical, and electrical testing, special laboratories being suitably equipped for this purpose in the Council House buildings. In November, 1916, Dr. Walter was appointed Engineer in Charge of these Laboratories, which have since been extended from time to time. During the latter part of the war he was requested by the Ministry of Munitions to act as Arbitrator in the carrying out of a complete series of tests on gas-heated furnaces, which covered the testing of practically the whole of the best designs of furnaces available at that time. Dr. Walter has always been interested in the Junior Sections of various Engineering Societies, and, in particular, the Junior Institution of Engineers. He was elected President of the Midland Section during the years 1926-27 and 1927-28. He is also an Associate Member of the Institution of Electrical Engineers.

The use of gas for propelling motor vehicles is, of course, by no means new; but the whole position has been transformed as the result of the manufacture of special alloy steels having remarkable properties—for example, a yield point of 59·5 tons per sq. in.; a breaking stress of 67·9 tons per sq. in.; an elongation of 22·8 p.ct. And Dr. Walter concludes the section with details of these storage bottles.

At present the regulations which apply to the transport and storage of gases in steel bottles do not cover the requirements of this special application of town gas at high pressure, but it is anticipated that at an early date sanction will be given for high-tensile steel bottles of approved design to be employed in connection with passenger-carrying vehicles.

Increase the Efficiency of Appliances.

The first speaker in the discussion was Mr. Stephen Lacey, who suggested that there might be the danger of those responsible for small undertakings, having no large factories in their areas of supply, arriving at the conclusion that there are no opportunities for expansion of industrial sales—an idea, however, far from the truth. The speaker laid great emphasis on the need for increasing the efficiency of gas using appliances as a primary step; reduction in the price of gas is a secondary consideration. In regard to competition, he observed that with the very large units oil was the competitor; with very small ones, electricity. We are on the firmest ground with medium-sized industrial gas appliances. Improvements in appliances can be made, in which connection Mr. Lacey referred to the series of small furnaces which have been designed for mass production and which we have already described in the pages of the "GAS JOURNAL" and "Gas Salesman." Another topic touched upon by Mr. Lacey was central heating by gas, a field of enormous possibilities; and he suggested that in this regard Dr. Walter is pessimistic in putting forward 4d. per therm as an economic price for gas in competition. He also urged his listeners to bear in mind that coke is also in the picture, and that its use may be greatly extended by the adoption of thermostatic control on coke burning appliances. Finally, Mr. Lacey, discussing the application of gas as a motor fuel, said there appears to be a promising field where the recharging of the cylinders on vehicles more than once a day presents no insuperable difficulty.

Experience at Tottenham, where valuable pioneer work has been accomplished, was referred to by Mr. H. C. Smith. Here actual road trials are being carried out on a 3-ton lorry, and an illustrated account of the equipment and also of the general results of the trials to date was published in the "GAS JOURNAL" a fortnight ago.

"Serious Damage; Slanderous Competition."

Mr. Lacey's remarks on efficient apparatus were corroborated by Col. W. M. Carr, and exemplified by reference to the industrial load at Stretford. As to compressed gas, Col. Carr asked that consideration be given to its use on the railways as well as on the roads; and he suggested that in the former application the weight of the containers is not of such vital importance. Mr. C. A. Masterman emphasized that the notion that central heating by gas is essentially linked up with a boiler is to impose quite an unreal limitation on the methods of the application of gas for this purpose; and he, too, thinks that 4d. a therm as a prior condition indicates pessimism. Comparative costs of different fuels, he was at pains to point out, have to be handled cautiously, for figures are all too familiar purporting to give comparative costs but actually showing the costs of a modern appliance using the fuel advocated against the costs of an entirely obsolete appliance using rival fuels. Mr. Masterman is convinced that out-of-date gas apparatus constitutes "our most serious damage and slanderous competition." A tribute to the constant help given by the Birmingham Gas Department was paid by Mr. T. P. Ridley, who told the meeting something of what is being done in Newcastle to retain and develop industrial gas business. Newcastle, with its industrial demonstration room, is a centre for the development of industrial gas. Several neighbouring undertakings are subscribers to this centre, and Mr. Ridley expressed the hope that other districts would soon establish centres on similar lines and so arrive at valuable co-ordination. In Newcastle, we learn, a start is soon to be made with experiments on the use of gas for motor traction. The 'bus stations in the Newcastle Company's area consume about 5 million gallons of petrol per annum, equivalent to approximately 1000 million c.ft.

F. P. TARRATT, M.Inst.C.E.

Mr. Tarratt was trained under the late Mr. Alfred Colson, M.Inst.C.E., at Leicester, and was appointed Engineer and Manager at Darlington in 1898, taking up the position of Chief Engineer with the Newcastle and Gateshead Gas Company in 1921. During the period he has been with the Newcastle Company they have taken over the Walker & Wallsend, the Chester le Street, and the Tynemouth Undertakings. Mr. Tarratt is a Member of the Institution of Civil Engineers, and holds various official positions in connection with the Federation of Gas Employers and the National Gas Council.

of gas. "Multiply this all over the country," said Mr. Ridley, "and we get an astounding picture." On the general question of industrial gas prices the speaker has come to the definite conclusion that, so far as it affects his area of supply, the industrial group of consumers as a body are paying too high a price and are carrying the burden of other consumers who are uneconomical. Hopes for the future of compressed gas are held by Dr. J. G. Stewart, who believes that higher efficiencies are obtainable in high-speed internal combustion engines. A matter to be investigated is the efficient mixing of gas and air at all engine speeds.

Industrial Centres Lagging Behind.

In a spirited speech Mr. W. B. McLusky advanced figures of consumption to demonstrate that industrial centres are lagging behind residential areas. In the country as a whole the average consumption per consumer is only a matter of 3 c.ft. per hour, and this includes both domestic and industrial loads. He quoted several figures relating to the average consumption per consumer per annum of different undertakings in residential and industrial areas, and he concluded very simply: If the price of gas is too high, it is mainly because the consumption is too low; the only way to reduce the price is to increase the consumption—and this will not take place if the price of gas is kept at a high level.

Mr. J. T. Haynes interested the meeting by the success which has rewarded the efforts of the Rotherham Gas Department to sell gas to industry. A schedule of gas prices for large consumption magnanimously allowing a 20 per cent. discount off standard domestic prices simply will not cut any ice. "I can assure you," he remarked, "that gas at 1½d. a therm has not been offered by the Rotherham Gas Department in any spirit of bravado." The gas undertakings who continue to nibble at the industrial cheese with only delicate scales of discount will never satisfy their hunger for large industrial loads. Certainly Rotherham are not nibbling. Last year the industrial gas consumption in their area increased by 25 per cent. and represented 48 per cent. of the total output; and increases of a like nature are confidently anticipated for the current year.

New Officers.

Before the meeting concluded on Tuesday afternoon, the President announced the report of the Scrutineers of the ballot for Officers, Auditors, and Council. The election are:

President.—Mr. Ralph E. Gibson.

Junior Vice-President.—Mr. C. Valon Bennett.

Auditors.—Mr. H. D. Madden and Mr. A. Morland.

Hon. Secretary.—Mr. W. E. Price.

Ordinary Members of Council.—Mr. J. R. Bradshaw, Mr. David Fulton, Mr. H. C. Smith, and Mr. John Terrace.

District Members of Council.—Messrs. J. Green, Wisbech (Eastern Counties); F. J. Edmunds, Waterford (Irish); C. W. Ward, Wakefield (Manchester); E. B. Tomlinson, Birmingham (Midland); A. S. Nisbet, Paisley (North British); A. C. Hovey, London (North of England); R. H. Ruthven, Ramsgate (Southern); and E. Ablett, Swansea (Wales and Monmouthshire).

The names of the Hon. Members, Members, Associate Members, and Associates who were elected will be found on another page of this issue.

How to Make Cheap Gas.

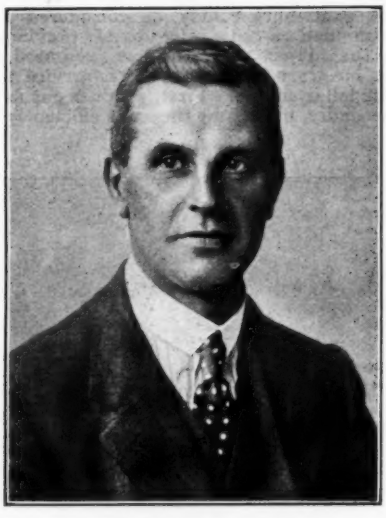
The first item on the programme on Wednesday morning was a paper by Mr. J. E. Blundell, of Carlisle, entitled "Ten Years' Carbonizing in Vertical Retorts." An equally suitable title, we suggest, would be "How to Make Cheap Gas." The author has had a great deal of experience in the working of Glover-West continuous vertical retorts, and his present contribution may be considered as both an amplification and a summing-up of previous valuable papers on the subject which he has presented at District Association meetings. The idea of gas service as expressed by Mr. Blundell is simple. First, produce gas as cheaply as possible; secondly, utilize the therm as efficiently as possible

C. VALON BENNETT.

A son and brother of living Gas Engineers, Mr. Bennett is a grandson of Mr. W. H. Bennett, who was for many years Secretary to the Incorporated Gas Institute. He trained at the works of the Herne Bay Gas and Coke Company, and was subsequently appointed Assistant Engineer and Manager to that Undertaking. In 1910 he became Assistant Engineer and Manager of the Dartford Gas Company, which Undertaking later amalgamated with the South Suburban Gas Company. In 1913 Mr. Bennett was selected from a large number of applicants for the post of Engineer to the Rochester, Chatham, and Gillingham Gas Company. In 1918 he was appointed General Manager, and in October of that year became Secretary; and he now occupies the three positions. Great extensions and developments have been carried out at Rochester since 1913. The make of gas in 1912 was 573 million c.ft., while by 1931 it had risen to 1057 millions. During a part of the war period Mr. Bennett served as a Commissioned Officer in the Royal West Kent Regiment. He was President of the Southern Association of Gas Engineers and Managers in 1928, and is a Member of Committee of the British Commercial Gas Association, the National Gas Council, and the Federation of Gas Employers.

both domestically and industrially; thirdly, employ first-class salesmanship. It is with the cheap production of the therm that he deals in his paper. With a declared calorific value of 450 B.Th.U. he has for several years maintained in a plant brought into operation in 1922, of a nominal capacity of 2½ million c.ft. per day (actually, it could produce 3 million c.ft.), a total cost of gas manufacture of 1·13d. per therm. Maintenance costs for nine consecutive years show that the maintenance of the brickwork in the settings and producers cost 7·08d. per ton of coal carbonized, or 0·08d. per therm, and that the total maintenance of the plant, including coal and coke handling machinery, cost 10·21d. per ton of coal carbonized, or 0·11d. per therm. The life of the retorts has generally been 2000 days, equivalent to a duty of 4500 tons of coal carbonized.

This, it will be admitted, is good working, and a complete vindication—if, indeed, at the present any vindication is necessary—of the efficiency and economy of continuous vertical carbonization. Ease of working, too, is an important point brought out in the paper, for the record of calorific value determination shows the constancy of the calorific value of gas made and supplied at all times. When the plant was installed it was anticipated that on a 400 million c.ft. annual make the saving would amount to approximately 10d. per 1000 c.ft. The actual figure realized is 12·6d. All this is very straightforward, but it implies a great deal. It implies, for example, extreme care in the choice of coal for gas making, a matter which is considered in some detail by Mr. Blundell. New coals which may be



J. E. BLUNDELL, M.Inst.C.E.

Educated at Southport, Mr. Blundell served under Mr. John Booth, and then under Mr. John Bond, Past-President of the Institution of Gas Engineers. In 1914 he was appointed Gas Engineer and Manager at Macclesfield. Four years later he was appointed Engineer and Manager to the Carlisle Gas Department, and there he erected complete new gas-works, which were opened in September, 1922. Mr. Blundell was President of the North of England Gas Managers' Association in the session 1922-23, and President of the Cumberland and Westmorland Gas Managers' Association during 1928-30. In February, 1930, he was elected a Member of the Institution of Civil Engineers. He has served six years on the Council of the Institution of Gas Engineers, and is a member of the Central Executive Board of the National Gas Council, the Central Committee of the Federation of Gas Employers, and the National Joint Industrial Council for the Gas Industry.

offered are put through searching tests both on a small and a large scale to ascertain their behaviour, and only if the results on the full scale are good is any contract placed for supply over a lengthy period. Details of manufacturing costs are set out clearly in tabular form, and speak for themselves.

Steaming and the Coke Market.

The author is faced with severe competition from coke ovens in the coke market, and this led him to investigate closely the costs of the therm in relation to the difference between the average price at which he could sell coke and the cost of his coal. Particular stress is laid on the average net price of coke, which takes into consideration both export and home prices; and the author shows that with coal at 20s. a ton and with coke at less than 22s. per ton the cheapest therm is manufactured at a calorific value of 450, provided that the thermal production per retort is not reduced. On the other hand, graphs reproduced in the paper indicate that if coke realizes an average price of 23s. or more per ton, the therm can be made more cheaply at 500 B.Th.U. than at any lower value, even though the number of therms made per ton would be considerably less. At present the author has no plant which makes it possible to supply coke in carefully selected sizes. He merely screens it over a ¾ in. mesh and does not grade it in any way. Experience elsewhere indicates that the coke position in Carlisle might be modified if such plants were installed. However, Mr. Blundell has some very interesting comments on coke breeze and dust—two gradings which ought not to be confused. He regards breeze as anything through a ¾ in. mesh but over ¼ in. mesh; the rest is dust. And he speaks of experiments which show that a step-grate built-in producer of the type commonly used with vertical retorts has been operated for some weeks under pressure and successfully used fuel passing through ¾ in. mesh and containing 30 p.ct. of dust. "It is possible," he observes, "that there may be sufficient breeze in the whole of the coke produced to provide the necessary fuel for the producers. But even if that were not so it would certainly seem to be practicable to increase the size of the breeze screen to, say, 1 in. mesh, so that all of the coke over that size would be available for sale and would command the top market price." The author speaks highly of the lip-bucket conveyors installed at his works. They have handled nearly half-a-million tons of coal and coke since they were erected, and have cost not more than 0·14d. per ton of material conveyed. Control of the coke market by extended steaming of the charge led the author to investigate the practicability of making gas at 400 B.Th.U. per c.ft. enriched with oil. Technically the practice is good; economically, however, the method is unprofitable at the ruling prices of oil and coke. Mr. Blundell sells his tar in the crude state, but is fortunate in obtaining a good price for it; his ammoniacal liquor, in common with so many other undertakings, is valueless.

The foregoing is a bald statement of a paper which shows how cheap gas may be made and sold. That the author's policy in regard to both the manufacture and distribution of gas is the right one is demonstrated well enough by the gratifying increase in sales during recent years. In particular we like Mr. Blundell's spirit of enterprise in regard to main laying. And here we cannot do better than quote the following sentence from the introduction to his contribution. "Since then [*i.e.*, 1925] mains have been extended and enlarged and now supply gas to every centre of population, however small in number, within the authorized area, with a definite policy that no reasonable opportunity must be lost of staking out the claim for gas for every domestic and industrial purpose within the area." There are, of course, points about the paper which have local rather than general significance. The low temperature at which the author works his settings is rendered possible by the coals he employs. As an interesting point of detail, Mr. Blundell gives a description, illustrated by a diagram, of an automatic coke skip filler.

There is a Market for Good Coke.

The discussion on the paper was opened by Mr. Gibson, who, having congratulated the author on his results over such a long period—quite a different matter from a short test when a plant is in new condition—referred especially to the production of a satisfactory high-temperature solid smokeless fuel in horizontal retorts at Liverpool. Many of our readers will be aware that for some time now Mr. Gibson, by the careful choice of coals and equally careful blending, has been making a fuel, known as "Dryco," which has already proved highly popular among his domestic consumers. Further particulars relating to the success which has attended his efforts were given by Mr. Gibson, who said that this fuel, of which he had sold thousands of tons, has displaced the use of raw coal in a great many households. It costs more to produce than ordinary coke, but he is able to get about £1 per ton more for it than for export coke. "Our experience at Liverpool," he remarks, "has clearly demonstrated that first-class solid smokeless fuel can be produced by high-temperature carbonization if the necessary care is taken."

Mr. Tarratt then outlined some of his experiences at Newcastle, where he has both horizontal and continuous vertical plants. He is using Durham coals, which are difficult to steam; and he finds that if he steams to keep his gas below 500 B.Th.U. the quality of the coke suffers materially, and he is well satisfied with 75 therms per ton of coal making a 500 B.Th.U. gas. As a result of his work he has arrived at the conclusion that there is very little difference between the standard of the results which can be obtained either from verticals or horizontals; and this applies to both tar and coke. Some of the consumers in

his area prefer vertical coke, others horizontal coke, which they absolutely specify.

Mr. W. B. McLusky, who paid some very nice compliments to the author, expressed the opinion that continuous vertical retorts improve the quality of the coke, which is discharged from the retorts with a low moisture content and a lower ash content than would be possible had the coke been made by carbonizing a static charge. His idea is that the motion of the charge in the continuous vertical retort loosens the ash in the natural bands of coal, and this ash falls away in the coke dust. Wet washing of coals, he pointed out, can only reduce the extraneous ash of the coal. Mr. McLusky, however, did not mention the proportion of breeze made in his vertical retorts as compared with the amount of breeze from the same coal carbonized in, say, intermittent vertical chambers; and this must have a most important bearing on the matter. "In Halifax," he said, "we adopted continuous vertical retorts not because we were dissatisfied with horizontal retorts, but because we wanted a purer stream of gas in the town."

Why Not Remove the Carbon Dioxide?

The next speaker was Mr. S. Tagg, who remarked that at the present time the cheapest therm can be produced in low-grade gas, but that naturally the price at which the therm can be supplied at the consumer's burner depends not only on the cost of manufacture, but also on the cost of distribution, which naturally increases as the volume of gas required to perform a certain amount of work becomes greater. But, asked Mr. Tagg, why not lower the amount? The nitrogen content can be kept at a low figure if the technical supervision of the carbonizing plant is of a high order, and the carbon dioxide could be removed. Such removal could be effected by washing with a solution of alkali carbonate—either sodium or potassium—and heating the bicarbonate formed to remove the carbon dioxide, so completing the cycle.

As a matter of fact, Mr. Blundell had been given prior notice of this question, and was able to give some useful information in relation to his practice at Carlisle. His gas contains 4 p.ct. of CO_2, and he can steam to 435 B.Th.U. without any increase in this percentage, and if the whole of the CO_2 was removed it would bring back the calorific value to 453 B.Th.U.—that is, suitable for the declared calorific value of 450 B.Th.U. Reduction in the specific gravity of the gas would be equivalent to a 3·6 p.ct. increase of the capacity of the distribution system; the coke for sale would be reduced by 1630 tons a year; and the net cost of coal by £760, which is equivalent to 0·307d. per 1000 c.ft. of gas made. Hence, unless CO_2 elimination could be carried out at a cost of 0·3d. per 1000 c.ft. in this case, there would be an increase in the cost of gas into holder. However, it appears to Mr. Blundell that the whole question might usefully be investigated by a Research Committee of the Institution.

Coke Breeze for Producer Gas.

Mr. F. B. Richards spoke of the influence of breeze on the net return for coke, and of the practicability of using a good deal of breeze in producers for heating the setting. Having commented on the fact that the term "breeze" is used very loosely (if dust under, say, ¾ in. is removed, breeze is really a very good fuel which can be used readily on step grates), he cited instances of the success which has attended the use of breeze in step-grate producers. In one case a very large plant was run for a whole week with fuel passing 52 p.ct. through ¾ in., while another plant ran for a considerable period with a fuel which passed 50 p.ct. through ¾ in. and 25 p.ct. through ¼ in.

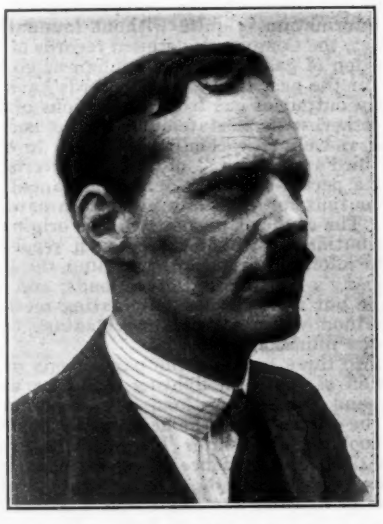
Particulars of the use of breeze in producers were forthcoming from Engineer-Capt. J. Fraser Shaw, of the Fuel Research Board. His contribution is, indeed, of the greatest importance. For the last six months he has been using horizontal retort breeze for making producer gas for power purposes. On a test lasting 144 hours the analysis showed over 54 p.ct. through ¼ in. mesh. The ash content was about 12 p.ct., and the plant used, which had a capacity of about 500,000 c.ft. of gas per day, was actually a small Humphreys & Glasgow water gas plant. The secret of the success is the introduction of up-and-down running on this producer gas plant, just as if it were a water gas plant, the cycle being 10 minutes up and 10 minutes down with 2½ hourly charging. On the actual test he was burning 16 lbs. of breeze per sq. ft. of grate area, but he can burn nearly 22 lbs. per sq. ft. under different conditions. Captain Fraser Shaw believes that there is every prospect for any type of breeze being dealt with comfortably by this method.

More Messages of Goodwill.

Following the President's announcement that, on behalf of the Institution, he had sent their cordial greetings to the Canadian Gas Association on the occasion of their Annual Convention at Winnipeg on June 9, the Secretary read messages of good wishes which had been received from the American Gas Association, the French Gas Union, the Belgian Association of Gas Engineers, the Gas and Water Association of Czecho-Slovakia, and the Gas Association of Yugo-Slavia. Later in the week came greetings from the Polish Gas and Water Association.

Gas Fire Flues.

The memorable contribution of Messrs. Masterman and Dunning at the research meeting last November led us to anticipate another work of high importance and interest and of great practical significance; and our hopes are realized in the paper on gas fire flues and ventilation by Mr. C. A. Masterman and Mr. T. G. Noble, presentation and discussion of which brought Wednesday morning's session to a close. The authors review the conditions



C. A. MASTERMAN, M.A. (Oxon.), F.I.C.

Mr. Masterman was educated at Gresham's School, and gained a Natural Science Exhibition, Balliol College, Oxford, in 1914. He served as Captain with the 1st Battalion The Hampshire Regiment, in France, until wounded in 1916. Later he was attached to the F.S.C., R.E., France, on sound ranging. After the war he resumed his studies at Balliol College, reading chemistry. After taking the Degree of B.A., he remained at Oxford on research for the War Office, and later was appointed Senior Assistant in the Defensive Munitions Department, at the Experimental Station, Porton. Mr. Masterman joined the Gas Light and Coke Company in 1927, becoming Senior Chemist in charge of the laboratories at Watson House, engaged on research and testing in connection with gas appliances and other utilization problems.

T. G. NOBLE, B.A. (Oxon.).

Mr. Noble received his early education at Varndean School, Brighton, and in 1924 gained an Organ Scholarship to Balliol College, Oxford. From 1924 to 1928 he read Chemistry in the Honours School of Natural Science at Oxford, taking the Degree of B.A. (1st Class Honours) in 1928. In the latter year he joined the Gas Light and Coke Company as Chemist at Watson House.

governing the ventilation induced by gas fires fitted to flues, the main factors, broadly in the order of their significance, being cross-sectional area of the flue, heat input, and height of flue. It is pointed out that considerable structural economies are rendered possible by the use of gas fire flues of small cross-sectional area compared with the minimum sizes possible with solid fuel fires, and that the air movement produced by these small flues is greatly in excess of that required to remove the products of combustion from the fire. The effects of restrictions in the flue are analyzed, the most significant being the flue spigot of the fire itself if this is sealed to the flue. Tables are given of critical dimensions, under practical conditions, to produce two or four air changes per hour; and the flue dimensions are derived and expressed graphically for any appliance in relation to the gas rate and operating conditions. In brief, the paper gives precise information on a subject on which the success of gaseous heating depends.

Speaking of wind effects, the authors devote some attention to static pressure, observing that if the flue terminal is on the windward side of a building in a position where the wind is trapped and actual air movement is nearly absent, no special terminal can effect a cure. Another position must be sought for the termination of the flue—it may be a few feet distant only—in a zone where the air is moving and the static pressure is consequently less. The instinct to avoid exposed positions for the terminal is definitely unsound. "While," state the authors, "there can be no sound hygienic reason for demanding the complete removal from the room of all the products of combustion, such removal, in the absence of cross draughts in the room, is so easily accomplished with modern gas fires that a 100 p.ct. standard has become accepted."

The inset type of gas fire designed to be fitted into an existing opening and having no canopy of its own is becoming increasingly popular. Doubts have been expressed as to the capabilities of such fires to direct their products up the chimney. Tests have shown, however, that the behaviour of inset fires is much more reliable in this respect than has been supposed, and that the controlling feature is the height rather than the projection of the canopy or lintel. Provided this height does not greatly exceed 2 ft. above floor level, a flue which is capable of inducing physiologically acceptable ventilation will be found capable of removing all the products of combustion from the normal types of inset fire. "The tradition of air contamination at one time associated with gas fire installations must now be discarded, and the cause of such contamination, if and when it does exist, must be traced to the positive defect which is responsible and which can and must be corrected."

In a section on "flue dimensions and ventilation" the conclusion is drawn that ventilation in any room should be at a maximum compatible with adequate heating and the absence of uncomfortable draughts. Over five air changes per hour may easily lead to discomfort, while under two changes will usually be inadequate in an occupied room. In the absence of a flue, less than half this suggested minimum may exist if doors and windows are shut. The flue should therefore be capable of inducing between two and four changes per hour if ideal conditions are to be obtained.

The fitting of a ventilator into the flue just below ceiling level has sometimes been advocated as a desirable auxiliary, one result of which will be to diminish draughts at floor level. The authors observe, however, that if the ventilator is of sufficient size to be of use, the result will be to diminish the effective height of the flue, so that if the height above the vent is very short the decrease in induced ventilation may be considerable.

The Nose as Indicator.

A great deal of the discussion on this paper was confined to points of detail or criticism of methods of calculation, but Sir Leonard Hill generalized from the particular—the particular being his own nose. Comfort in heating of any type is due generally to a group of infra-red rays in the region of 20,000 to 30,000 Angstrom units, and this group is present in the gas fire of modern design. Any source of dull heat, whether it be electric radiator, steam heater, or any other type, causes him discomfort through lack of these rays, though the effect of the discomfort is counteracted by cool air acting on the skin. Thus there must be plenty of air to counteract any dull red source or black source of heat. Sir Leonard Hill put forward an interesting reason why, in time past, people put in front of their gas fires a trough of cold water. The reason, he said, is that certain rays reflexly produce discomfort, and the water vapour rising from the trough in front of the fire acts as a screen and absorbs these rays.

Dr. Walter thinks that the authors laid hardly sufficient stress on the need for adequate air outlets, and he suggested that where the ventilation force of a fire is low, suitable ventilating ducts in various parts of the room might be installed, fitted with suitable controls. Another suggestion he made was that, by an arrangement of control of the inlet air with gas fires, the inlet air velocity might be considerably reduced, and a more even distribution obtained which would result in draughts being reduced to a minimum or entirely eliminated. He also spoke on the question of increasing the radiant efficiency of gas fires without seriously affecting their ventilating effect, his inference being that there is still considerable scope for gas fire design, even on the present lines, without encroaching on the ventilating part of the problem. Still another suggestion is that we might extract from a room the foul air at a height above breathing level by installing suitable injectors operated from the waste gases of the fire.

Prof. J. W. Cobb, who spoke of the work on the subject which has been carried out over a number of years at Leeds University, said that sight must never be lost of the fact that the modern gas fire is not only a source of the supply of radiant heat, but that it is also an effective ventilator; and he thinks it would be a pity if the paper were used to justify any tendency to cut down to the closest point the capacity of the ventilating flues used in connection with gas apparatus. There is, he thinks, a temptation to press too far the possible advantages to the Gas Industry that may be secured in building construction by the use of small flues of a certain shape.

In his reply, Mr. Masterman said that he is definitely aiming at cutting down the size of the flue; he is aiming at giving data which will be a definite guide, so that builders will know what size to use to obtain the required ventilation; and the fact does emerge that one can effect very considerable economies indeed by using surprisingly small flues. It is no use building large flues and then blocking them up and so reducing the ventilation because there is an excessive draught; we may as well effect economies in the actual construction. As a result of the work he has carried out, the builder is given guidance as to the size of the flue he should use to produce normal ventilation.

Dr. Harold Hartley, referring to the suggestion made in the paper that the *complete* removal of products of combustion of a gas fire from a room is really unnecessary, said that, while this may be true with a fire correctly designed and operating properly, it must not be overlooked that gas fires are often used in a badly adjusted state and with broken radiants. If the view were to gain ground that the advance represented by the "Lancet" test is of little moment, it would be unfortunate.

Statistics and their Analysis.

The first paper to be presented on Thursday morning was by Dr. J. S. G. Thomas, who demonstrated clearly enough that as far as his Company—the South Metropolitan—is concerned, any criticism that our Industry does not pay enough attention to the compilation of necessary statistical information is quite without foundation. As a matter of fact, the Company's detailed records of the supply and installation of gas consuming appliances go back forty years, and for the past thirty years records have been kept of the hourly output of gas from all stations of the undertaking, together with a statement of the corresponding atmospheric and climatic conditions. And, to obtain at a glance a "bird's eye view" of the characteristics of the supply over a period of a year or so, permanent records of the hourly output for each day are cut in cardboard and assembled. The author's purpose, in this original and welcome contribution, is to show how such records may be employed to afford information regarding the proportions of the Company's lighting and other loads; and the results of the simple but none the less fascinating method he employs—a method which all gas undertakings could apply with ease—are illuminating.

Divided into three sections, the paper deals in turn with the derivation of the total lighting load, the variation of the output and the lighting load over a period of thirty years, and the estimation of the heating and domestic loads, including cooking and water heating. Naturally, compared with 1903, the incidence of the lighting load at the present time is not so great. The percentage of the total output used for lighting was 45 p.ct. for a day in December, 1903, and 25 p.ct. for a day in June. The corresponding figures for 1931 are 23 p.ct. and 8 p.ct.; but they represent an output of gas which fully justifies our unwavering insistence on the value of the lighting load and the need for doing all possible to retain and develop it. The graphic method used shows the effect of Summer Time—a reduction in the lighting load by about 2 p.ct. of the total output; and in this connection the accuracy and possibilities of the deductive method are well brought out. The possibilities of the "detector" are indeed full of interest. Among other matters, for example, the graphs provide clear evidence of the decreased "home-staying" habits of the people in recent years associated with the growth of attrac-

tions such as super-cinemas and dog racing. Again, a glance at the graphs shows when people are away from home, and when they return. In one of the diagrams relating to August Bank Holiday of last year the incidence of the late return of revellers to their homes after the holiday festivities is apparent.

A Tell-Tale Schedule.

The graphs demonstrate the tendency of the load to be levelled out in recent years, attributable in part to an increase of the heating and cooking loads, and in part to a decrease of the total lighting load. As to the cooking load, the marked feature is its comparative constancy throughout the year, though the gas output records referring to very recent years suggest a slight reduction in the load, doubtless associated with the changing social habits of the community. Concluding his paper Dr. Thomas draws up a complete schedule of the distribution of the total load among the various uses of gas on two days—one with a temperature of 42° Fahr., the other 78° Fahr. The following figures extracted from the schedule tell their own story:

	A Day in March, 1931. Temp., 42° Fahr. P.Ct. of Total Load.	A Day in August, 1930. Temp., 78° Fahr. P.Ct. of Total Load.
Domestic lighting	16·4	13·9
Public ,,	2·3	2·9
Industrial uses	7·0	8·4
Domestic heating	25·8	..
Cooking (including water heating)	48·5	74·8

Fixed Gas and Air Burners.

Money is not plentiful in the district supplied by the South Metropolitan Gas Company, and gas lighting is popular and is likely to remain so. This fact was referred to by Mr. E. V. Evans, who was the first speaker in the discussion. He is of the firm belief that a fixed air and gas supply of burners is helping largely to retain the lighting load. This, of course, necessarily implies strict control at the works of the calorific value, composition, and specific gravity of the gas manufactured; but this is all in the best interests of the consumer. The specific gravity of gas supplied is altered by the addition of water gas, manufactured to control the coke market, and Mr. Evans cannot understand why there should be difficulty in selling good coke. Moreover, with care, such coke can be made; as he says, the field for coke sales is as yet untapped. Already gas as an illuminant is far more comfortable than any other to the human organism; and we have by no means reached finality. It may be that gas lighting in the future will be carefully arranged in regard to spectral distribution by modifying the composition of the mantle and equipping the lighting unit with a scientifically coloured reflector, so that a wonderfully soft and pleasing light may be produced.

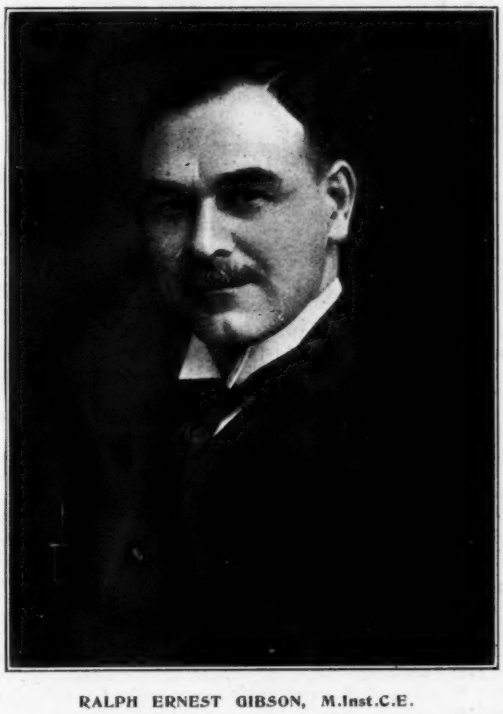
Having commented on the graphic interpretations of Dr. Thomas, and explained that for several years now he has adopted similar practice with beneficial results, Mr. Stephen Lacey congratulated the South Metropolitan Gas Company on having a lighting load equivalent to 16 p.ct. of the total output. The corresponding figure for the Gas Light and Coke Company is 10 p.ct. He gathers that, of the total output to the prepayment consumers in the South Metropolitan Gas Company's area, 20-25 p.ct. is due to lighting. The author, continued Mr. Lacey, spoke of gas lighting as quite distinct from gas heating; but it is not correct to separate them so absolutely, for the heating value of gas lighting is a useful advantage. It is where one can place a money value on this warmth that gas is in its strongest position for lighting. The adoption of electricity means not only higher costs for lighting, but also higher costs for heating; and the speaker concluded his remarks by citing examples of the illumination of churches to amplify his contention.

Members were glad to have with them Mr. W. J. A. Butterfield, one of the Gas Referees, who emphasized that loss of the lighting load implies much more than the consumption it represents. He mentioned the instance of an undertaking which adopted the policy of neglecting the lighting load in the hope of catching bigger game; but he is sure that this policy was not of real advantage, and that the decrease in cooking and heating consumption in those homes where gas lighting was not used would in aggregate represent more than the additional load of the larger industrial consumers. After all, the installation charges for two distinct sources of energy—gas and electricity—are too great in relation to the total rental of small dwellings, and it would be a good thing for the Gas Industry if it emphasized that gas lighting is not merely economical, but is the most comfortable means of illumination. And in the retention and development of the lighting load greater attention should be paid to the improvement of the gas switches, particularly to the introduction of gas switches requiring no by-pass.

Mr. Robert Watson, who spoke of the utility of the output curves such as those produced by the author, which are of great value in enabling us to concentrate properly on the valleys of the curves, referred to the good work of the Joint Lighting Committee of the Institution. The

THE NEW PRESIDENT.

Mr. Gibson is Chief Engineer to the Liverpool Gas Company, the largest of the Company-owned Undertakings in the Provinces, having an annual output of over 8000 million c.ft. of gas. His connection with the Company has extended over a period of nearly 28 years. He joined the Company in 1904, when he was appointed Assistant Engineer. For eleven years he was largely responsible, under the late Mr. Edward Allen, Chief Engineer, for the design and construction of extensive alterations and additions to the manufacturing plant, including a large amount of labour-saving machinery. On the death of Mr. Allen in July, 1915, Mr. Gibson was appointed Chief Engineer, and was responsible for the administration of the Company on the technical side during the difficult period of the war, continuing in that position up to the present time. During this latter period many improvements have been carried out. The carbonizing plant has been modernized throughout, the obsolete works at Caryl Street have been closed down, new coal gas-works have been constructed at Garston, the distributing system has been improved and greatly extended, and two Gas Undertakings have been absorbed—viz., Hightown Gas Company and Woolton Gas Company. One of the latest developments has been the production of the new smokeless fuel "Dryco," by high-temperature carbonization, which was the subject of a paper read by Mr. Gibson before the National Smoke Abatement Society last Autumn. Mr. Gibson is a member of the Institution of Civil Engineers, having previously been a Student and an Associate Member. He was elected an Associate Member in 1900 after passing the qualifying examinations. He was elected President of the Manchester District Institution of Gas Engineers in 1923 and President of the Liverpool Engineering Society in 1924. Mr. Gibson was educated at the Sheffield Royal Grammar School, and received his early training in the Works and Drawing Office of Messrs. Newton, Chambers & Co., Ltd., where he served a pupil-apprenticeship of six years. He was afterwards engaged for a period of four years on Messrs. Newton, Chambers & Co.'s staff in designing gas-works plant and other engineering structures, surveying sites, preparing plans, specifications, and estimates, and also in supervising erection. During this time he studied Mechanical Engineering and other subjects at the Sheffield Technical College. In 1899 he was appointed Engineering Assistant to the Huddersfield Gas Department, and for nearly five years was engaged there on renewals, extensions, and general supervision of the manufacturing plant and distributing system. From there he went to Liverpool. Mr. Gibson has contributed several papers on technical subjects to various Associations, the Liverpool Engineering Society having awarded him its Premium for a paper entitled "The Mechanical Handling of Materials on Gas-



RALPH ERNEST GIBSON, M.Inst.C.E.

Works," and the Institution of Gas Engineers the "H. E. Jones" London Gold Medal for a paper entitled "Construction of the New Coal Gas Works at Garston." He has served on many District and National Committees in connection with the Gas Industry.

South Metropolitan Gas Company, he said, are certainly to be congratulated on losing during the past ten years only 2 p.ct. of their lighting load. A point brought out by the author's curves, he continued, is the amount of gas used between midnight and dawn, which is due for the most part to public lighting; and the corollary to this is that the charges for gas for public lighting should be as low as possible.

The reply by Dr. Thomas was one of the brightest features of the meeting—his chief point being that the lighting load can only be retained by the sale of better burners by the Gas Industry itself. To-day the Gas Industry is not doing what it can in this respect; it has not put its own house in order. At the present time bad electrical lighting fittings simply cannot be purchased. The same comment does not apply to gas lighting fittings.

Results of a Determined Policy.

The final paper at the meeting was by Mr. W. Clark Jackson, of Neath, who demonstrates the progress which can be made by a small gas undertaking provided a constructive policy is pursued. We have long maintained that there is no reason why small gas undertakings should not be thoroughly efficient in relation to the circumstances of supply, and should not uphold worthily and effectively the

W. CLARK JACKSON, A.M.I.Mech.E.

Mr. Jackson was educated at Leven High School and Heriot-Watt College, Edinburgh, and was indentured as engineering apprentice with Messrs. Henry Balfour & Co., Durie Foundry, Leven, his training including drawing office, fitting shops, plant erection, &c. For two years he was Assistant Engineer to the Waterford Gas Company, and following this for three years he was Assistant Engineer to the Gosport Gas Company. Subsequently, and again for a period of three years he was Assistant Engineer and Deputy Manager to the Merthyr Tydfil Gas Company. In 1915 he was appointed Engineer and Manager to the Neath Corporation Gas Department, the position he now holds. Mr. Jackson is a Past-President of the Wales and Monmouthshire Association of Gas Engineers and Managers, and has been Hon. Secretary of the South Wales District Executive Board of the National Gas Council since 1920.

service motto of our Industry. Mr. Jackson's paper is proof that, with plenty of push and determination, there is ample scope for the small works, and his contribution was a most welcome one. The period of development considered by the author is from 1919 to the present time; and the results which have been achieved during that period may be summarized as follows: Complete modernization of works and plant; complete overhaul, renewal, and replacement of district mains, services, and meters; an increase in gas sales of 75 p.ct.; reduction of unaccounted-for gas from 21 to 9·7 p.ct., in bank overdraft from £21,897 to £2116, and in price of gas from 14·11d. to 10·59d. per therm; increase in sales of fittings and appliances from £1223 to £5282 per annum, and in gross profits from £3863 to £11,500 per annum; complete modernization of public lighting; and a general consolidation of goodwill. We regard this as no mean achievement; and at the meeting the author gave us the key to his success—enterprise and unbounded faith and enthusiasm.

In this review we cannot, of course, deal at all fully with the ground covered by Mr. Jackson, but one or two items call for special comment. His " free " maintenance scheme (actually this admirable service costs 0·41d. per 1000 c.ft. of gas sold), for instance, is exceptional in that the staff employed consists of women specially trained for the work. Five women inspectors are now employed. In the author's opinion the confidence which has been built up between the consumer and these inspectors is such that recommendations made by them, and which are all made following upon some definite selling policy, receive much more careful consideration than would be the case if this work of selling additional appliances was carried out by the usual type of canvasser salesmen. Then Mr. Jackson's account of the benefits which have accrued from the installation of naphthalene washing and gas drying plant adds further to an accumulating mass of favourable evidence. Apart from such advantages as longer life of mains and services, and greater customer satisfaction, the actual saving on the year ended March last is stated as over £700 on a plant of a capacity of 1½ million c.ft. a day. The author has a singularly happy story to tell in regard to gas lighting. At Neath, where the Electricity and the Gas Departments are both owned by the Municipality, the Gas Department has been successful in retaining gas in each of the 370 new houses erected at Neath and Briton Ferry, and we are glad to note that in each of the more recent houses the Department has included at its own expense a lighting switch.

Finally, the author is in the unusual position of being offered gas of a calorific value of 1550 B.Th.U. for industrial purposes; and if negotiations in this connection prove successful the ultimate industrial business likely to be obtained with the Neath district is in the region of 250 million c.ft. a year—practically equal to the output of the Undertaking for its domestic and heating business.

Salesmen All.

If we are to get the best sales results, it is necessary that every member of a gas undertaking should be a salesman. Fitters, for example, have unique opportunities of obtaining business. This was the keynote of Mr. Madden's contribution to the discussion. He recounted the results of co-operative work at Cardiff, where his fitters are full of enthusiasm and are doing splendid work. In regard to the sales of appliances, 1931 was a bumper year for the Cardiff Gas Light and Coke Company; and taking into consideration the depressed conditions of trade and the fact that income-tax payments in January proved no pleasure, Mr. Madden is to be congratulated on increasing his sales of appliances during the first three months of 1932. Actually there is an increase of 50 p.ct. Mr. R. Bruce Anderson spoke highly of the benefits of employing lady demonstrators by gas undertakings themselves, and cautioned his listeners in regard to employing stores systems so elaborate as to defeat their own ends.

Dr. E. W. Smith, who said how excellent the organization of the meeting had been in regard to the substance of the papers, remarked that the author had dismissed his carbonizing plant in a few words, and he (the speaker) assumed from this that Mr. Jackson's plant was so satisfactory that it gave him no trouble. However, Dr. Smith expressed surprise that the author had entirely ignored the question of coke sales, for he still believes that insufficient attention is paid to the coke market. In reply to this the author said he makes good coke quenched by low-pressure steam. He can sell his coke regularly at a good figure, and has, in fact, no difficulty with sales. Dr. Smith is of the opinion that all gas undertakings should dry their gas, for in every case the indirect advantages would justify the installation of gas drying plant. Mr. C. M. D. Belton made it quite plain that he has no soft spot in his business heart for lady maintenance inspectors, and he thought that the number of houses visited by each lady inspector at Neath indicated either that the work was superficially carried out or that few appliances were installed in the premises. With five maintenance men at Shrewsbury the time spent per visit is much greater. In his reply, Mr. Jackson maintained that for repetition work women are infinitely better than men, that maintenance work is for the most part repetition work, and that women are much more welcome in the house.

The various applications and the economic possibilities of oil gas of a calorific value of 1550 B.Th.U. per c.ft. were dealt with by Mr. W. H. Johns; and this terminated the technical business of the meeting.

Concluding Stages.

After the President had announced that the Research and Education Reports for 1931-32 will be presented at the Autumn Research Meeting in London on Nov. 1 and 2, 1932—a meeting which will be held at the Institution of Mechanical Engineers—Mr. Gibson rose to thank the members for the honour they had conferred upon him and the

GAS LIGHTS . . . . *by Fred May*

Published by the "GAS JOURNAL."

J. HERBERT CANNING, O.B.E.

Of Newport (Mon.).
President, Institution of Gas Engineers, 1931-32.

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Liverpool Gas Company in electing him President of the Institution of Gas Engineers. He expressed his full appreciation, and said he would endeavour to maintain the high standard set by his predecessors in office and to uphold the dignity and prestige of the Institution. He mentioned that it is just over 19 years since his predecessor at Liverpool, the late Mr. Edward Allen, was elected to the position. Mr. C. Valon Bennett also returned thanks for his election as Vice-President.

The President then explained that arrangements had been made for the Institution to visit Canada and the United States to participate in the meetings of the Canadian Gas Association and the American Gas Association in September and October of next year. The Council have already asked Mr. Tarratt, who, it is hoped, will be in the Chair at that time, to represent the Institution at the meetings in Canada and the United States. It is also hoped that at the time of the meetings a fellow-countryman, Mr. Arthur Hewitt, Vice-President of the Toronto Gas Company, will be President of the American Gas Association; and the meetings will coincide with the World's Fair at Chicago. Mr. Canning also reported that the Second International Gas Conference will be held at Zurich in September, 1934.

Then came a general vote of thanks to the representatives from overseas; Vice-Admiral Sir William H. D. Boyle, K.C.B., President, the Royal Naval College, and Lieut. G. Hunt, M.B.E., R.N., Curator, the Royal Naval Museum; the Council of the Zoological Society of London and Capt. W. P. B. Beal, Superintendent, Whipsnade Zoological Park; the Gas Light and Coke Company; the South Metropolitan Gas Company; the Hastings and St. Leonards Gas Company; Mr. Charles F. Botley and Miss Cicely M. Botley; ladies and gentlemen assisting in the conduct of the meeting; the authors of papers; the scrutineers of the ballots; the Officers, Auditors, Council, and Committees of the Institution; and the Secretary and Staff of the Institution.

The vote of thanks was proposed by Alderman F. J. West and seconded by Mr. J. W. Auchterlonie, and both speakers referred to the organizing ability of Mr. Alexander and the enthusiasm and devotion of his staff. Supporting the vote Mr. W. T. Dunn asked if the President could tell them when members of the Institution are likely to receive copies of the Transactions, to which Mr. Canning replied that one volume would be in the hands of members very shortly; and it is anticipated that all the volumes in arrear will be available before the end of the new Presidential year. Replies to the vote were made by the President and Mr. C. F. Botley.

Then the President-Elect proposed a vote of thanks to the President for his services during the past year and during the meeting. He congratulated Mr. Canning on the performance of the duties of the office with conspicuous ability and success. Mr. Canning, said Mr. Gibson, had upheld the high traditions of the Presidency and the prestige of the Institution on all of the many occasions when he had represented it, including his visit to America and Canada. In Committee the Institution owed much to his wise direction and calm unruffled demeanour, his devotion to the duties of Chairman, his courtesy, and his regard for others. All who had been associated with Mr. Canning felt very sorry that he would be vacating the Chair. When Mr. Canning relinquished the office which he had so well filled, and entered the calmer waters of ex-Presidency, it was hoped he would be blessed with good health and prosperity; and every member would wish the same for Mrs. Canning. Mr. Gibson then presented the retiring President with a Certificate recording his tenure of office.

In returning thanks to Mr. Gibson and to the members for their cordial reception of the vote of thanks, the President said: "A year ago I had the opportunity of thanking you for the very great honour you conferred upon me in electing me your President, and I can only say that on closing my year of office I feel as grateful as I was then. In fact, great as was my gratitude at that time it is still greater to-day, since I have experienced the unbounded kindness which members of the Institution invariably show to their President. In the Gas Industry we have a tradition of mutual kindness which is very creditable, but to feel it to the full one has to be President of the Institution. I can only say that I have experienced it to the full. . . . In taking leave of you I desire to refer to my successor, Mr. Gibson, in whom the Institution has one who is well known to all the members, a gentleman of very great ability, one whom all respect and esteem; and on your behalf I wish him and Mrs. Gibson a very happy and a very successful year of office. . . . To myself the past year, although a very strenuous one, has been a very happy one. This has been due to the support given to me by the Council, by the other officers of the Institution, by the Technical Press, and by friends in every quarter of the Industry."

Mr. Canning also expressed his cordial thanks to Mr. Price and to Mr. Alexander and his staff.

Forthcoming Engagements

June 18.—North of England Gas Managers' Association (Auxiliary Section).—Meeting at the works of the Washington Chemical Company, Ltd.

June 22.—S.B.G.I.—Council Meeting at 12 noon.

June 22.—Institution of Gas Engineers.—Meeting of Joint Lighting Committee, 28, Grosvenor Gardens, S.W. 1, 2.30 p.m.

June 23.—B.C.G.A.—Meeting of General Committee, 28, Grosvenor Gardens, S.W. 1, 2.30 p.m.

June 24.—B.C.G.A.—South-Western District Conference, Dartmouth.

June 24.—Waverley Association.—Annual Meeting in Edinburgh. Address by the President, Mr. James Bell.

June 29.—B.C.G.A.—Lancashire District Conference, Stockport.

July 1.—Southern Association of Gas Engineers and Managers.—Summer Meeting at Ramsgate.

July 1.—Manchester Association.—Visit to Wakefield. Inspection of Gas-Works and of Messrs. Terry, Greaves, & Co.s dry coal-cleaning plant.

Aug. 16 and 17.—Irish Association.—Meeting in Dublin.

Sept. 1.—Association of Statutory Meter Inspectors.—Annual Meeting in Edinburgh.

Sept. 8.—North British Association of Gas Managers.—Annual Meeting in Ayr.

The Institution Benevolent Fund

The General Meeting of the contributors of the Benevolent Fund of the Institution of Gas Engineers was held at the Park Lane Hotel, Piccadilly, W. 1, on Tuesday, June 7, 1932—Mr. J. H. CANNING (the President of the Institution) in the Chair.

The HON. SECRETARY (Mr. J. R. W. Alexander) read the notice convening the meeting.

The PRESIDENT: May I sign the minutes of the General Meeting held on June 4, 1931, as correct?

This was agreed to, and the minutes were duly signed.

The report stated that the number of cases assisted by the Fund in 1931 was twenty-one and the amount expended was £695 15s., as compared with £595 9s. spent in relieving seventeen cases in 1930. The expenses of the Fund have been confined, as is customary, to the necessary outlay for printing, stationery, and postage.

Visitors, appointed by the Committee, continue to call upon recipients and applicants, and render Visitors' Reports, which are of considerable assistance in deciding what grants can be made from the Fund. Grants are normally paid every calendar month, for the period ending on April 30 each year.

As a result of the special invitation issued to members of the Institution during the year, the number of contributors to the Fund in 1931 increased to 821, the corresponding figures being 720 in 1930 and 518 in 1929. The membership of the Institution is 1467. The Committee hopes that members who have not hitherto assisted the Fund will become subscribers, in order that it may continue to deal adequately with the deserving applications which are made for assistance.

Contributions received in 1931 totalled £782 12s. 2d. (being £519 1s. in subscriptions and £263 11s. 2d. in donations) as compared with a total of £729 17s. 6d. in 1930 and £554 8s. 5d. in 1929. Increasing use is being made of the bankers' orders forms obtainable from the Hon. Secretary, such forms presenting a convenient and economical method of subscribing to the Fund.

The Committee of Management expresses its gratitude to all contributors to the Fund, and is very appreciative of the continued assistance received from the District Associations. A third yearly donation of £100 has been received from Mr. Frank H. Jones, while Mr. Harold E. Copp, at the conclusion of his Presidency of the Institution, made a donation of ten guineas to the Fund.

The PRESIDENT: I beg to move "That the Report of the Management Committee for 1931-32 and the accounts for 1931, which have been printed and circulated among the contributors, be taken as read and adopted." The accounts are satisfactory inasmuch as they show a progressive increase in the subscriptions to the Benevolent Fund and also in the number of contributors. At the same time, the work of the Management Committee is to some extent hampered by the fact that they have to restrict grants in many worthy cases, and we should be very glad if members who have not hitherto contributed will become contributors to this Fund. For this purpose the office is open to receive contributions from members. I should like at this point to acknowledge two contributions to the Fund to-day. You will remember that some years ago Mr. Frank Jones promised the sum of £100 per annum to the Benevolent Fund, and I am glad to say that he has to-day paid the fourth of these contributions. I feel that we owe him a very deep debt of gratitude for his generosity to this very worthy Fund. [Applause.] The other contribution has been received from Dr. Hermann Müller, the Past-President of the German Association, and I feel that we owe him also our very best thanks for coming forward so generously, although he is not a native of our country nor a member of our Institution, and assisting this very worthy work. [Applause.] I do not know whether there are any points that anyone wishes to bring forward or any questions that anybody would like to ask, but we shall be very pleased to hear what any of the contributors may have to say with regard to the Funds and their application.

Mr. H. R. S. WILLIAMS (Altrincham): Although it may be satisfactory that the income is increasing and the number of members subscribing is also increasing, it seems to me that 800 out of a membership of 1400 is still very low—[Hear, hear]—and I should like to know if the Committee has considered any scheme for district or county collections—*i.e.*, a member of the District Association or, if you like, a member for each county should be appointed to see all the members in his county and try to increase the membership of the Fund. It seems to me that the membership is so poor at the present time that something ought to be done in that way.

Mr. C. S. SHAPLEY (Leeds): I should like to support what has just been said. When one looks at the list of subscribers and sees the small amount that some people subscribe I feel certain that the matter has only to be brought to their notice for them materially to increase their subscriptions. Lists have been circulated, and I do hope we shall all assist Mr. Valon Bennett, who has done such good work for the Benevolent Fund, by increasing our subscriptions to something like the level they should be.

The PRESIDENT: With regard to the question that has been raised, I may say that there is no organized scheme for raising subscriptions in the districts. We have received very valuable assistance from the Hon. Secretaries of the various District Associations, but I am quite sure the Committee is also quite prepared to consider some better organized scheme whereby we may increase the subscriptions.

If nobody else wishes to speak on this point, I should like to put the proposition to the meeting—viz., that the Report of the Management Committee and the accounts be adopted.

The proposal was carried unanimously.

The PRESIDENT: I will now ask the Secretary to report to you the result of the ballot for the elections to the Committee of Management for 1932-35.

The HON. SECRETARY: The scrutineers of the ballot report that Mr. Arthur L. Jennings, of Cleckheaton, and Mr. John Terrace, of London, have been elected to the Committee of Management for the years 1932-35.

VOTE OF THANKS.

Mr. A. VALON BENNETT: I have been asked to propose a vote of thanks to the Chairman, the Committee of Management, and the Hon. Secretary of the Benevolent Fund. It is rather extraordinary for me to be doing this because I happen to be a member of the Management Committee, or rather I was until two or three minutes ago when the new members of the Management Committee were announced. However, having served on the Committee for some years I would like, if I may, now that I am no longer a member of the Committee, to pay a tribute to all those who have had to deal with the work. Whatever President we may have had, and whatever members of the Management Committee we may have had, and whoever may have been the Hon. Secretary, I can assure you that the Benevolent Fund, which has always been very near to my heart, has always received the greatest possible assistance from all connected with the Committee. Everybody has been sympathetic, and the only thing they have been sorry about is that they could not do more for those who have applied for assistance. With that I beg to move a hearty vote of thanks to those whom I named in the first instance.

Mr. F. P. TARRATT (Newcastle-on-Tyne): I have pleasure in seconding that motion.

The vote of thanks was accorded with acclamation.

The PRESIDENT: I should like to thank you on my own behalf and that of the Committee of Management for the vote of thanks which you have so kindly passed to us. I do not wish to say much with regard to the President, who is *ex-officio* Chairman, but your Committee of Management has done admirable work for the Benevolent Fund. The only pity, as I have said, is that their efforts are hampered owing to lack of means. I am quite sure that if it were only possible for us to communicate to you the confidential information which reaches us with regard to cases with which the Committee has to deal, we should obtain a more gratifying and immediate response to the appeal for subscriptions. In conclusion, I should like to pay a tribute to the wonderful work done by Mr. Valon Bennett in support of this Fund. I know he does not like us to say anything about it, but I do not feel we should be acting fairly or justly if we did not say how much we appreciate what he has done to further the interests of the Benevolent Fund. Thank you very much, gentlemen.

THE OFFICIAL VISITS AND SOCIAL EVENTS

MRS. CANNING.

The President's Reception.

On the Tuesday evening the President and Mrs. Canning held a reception and dance in the ballroom of the Park Lane Hotel. There were as many as 780 acceptances for the function, and Mr. and Mrs. Canning began at 9 p.m. a very gracious reception of their guests. Mrs. Canning was beautifully gowned in blue satin, with a grey moiré silk coatee, and carried a bouquet of delphiniums and pink carnations presented by Mrs. H. D. Madden on behalf of the Wales and Monmouthshire Association of Gas Engineers and Managers. Dancing, to Jack Palmer's band, continued until 2 a.m.

Dinner to Past-Presidents.

There was an extremely pleasant function, on the Wednesday evening, in the White Room at the Savoy Hotel, when Mr. Charles F. Botley entertained at dinner his colleagues and friends the Past-Presidents of the Institution of Gas Engineers. Of these Past-Presidents there are twenty-three still living, and eighteen of them were present, while the remaining five sent greetings. Names and other details will be found in a leader entitled "Reminiscent."

President's Luncheon to the Council

At the close of the morning session on the first day of the meeting there took place in the Park Lane Hotel the President's luncheon to the Council, to which a number of distinguished guests were invited. After Mr. J. HERBERT CANNING had submitted from the Chair the Loyal Toast, Mr. RALPH E. GIBSON, President-Elect, proposed the toast of "Our Guests," remarking that there were present a large number of distinguished visitors whom they were very glad to have with them to do honour to their President, Mr. Canning. Also, he thought, their presence indicated a real interest in the welfare of the Gas Industry. The Gas Industry had never been more alive or more progressive than it was to-day. [Hear, hear.] Trade was in a deplorable condition, but the Gas Industry was holding its own well, in spite of the many adverse circumstances—including, of course, keen competition from other sources of light, heat, and power. Great strides had been made in recent years, not only on the production side, but also in the matter of sales organization, and the application of the Industry's products to industrial and commercial uses.

A REJUVENATED INDUSTRY.

One still found occasionally some benighted people who regarded gas as a relic of a bygone age; there was a great deal of ignorance existing in this connection. Such people did not realize that the Gas Industry was a rejuvenated industry, ready to give the best service to the community—service that they were able to render perhaps more efficiently and more effectively than any other industry. The greatest national asset of this country was coal and the Gas Industry was able to put this coal to use to the best possible advantage. Successive Governments had been slow to realize the potentialities of the Gas Industry. Mr. Canning, in his Presidential Address that morning, had referred to some public bodies who were allowed to go so far as to prohibit the use of gas for any purpose in certain dwellings. This was an intolerable position, and they were glad to note that it was being gradually broken down. With regard to the future, he did not think they had any need to fear, provided they secured fair play. They did not ask for any special favour, but they did want a square deal. The Gas Industry had played an important part in the great cause of smoke abatement, but he thought they had an even greater part to play in the future in the provision of solid smokeless fuels, not only for industrial purposes, but for domestic use. He coupled the toast with the name of Mr. J. R. Clynes, whose services to the State were fresh in the minds of all present. Mr. Clynes had also some connection with the Gas Industry on the labour side, for he was President of the Union which looked after the interest of gas workers throughout the country.

GOOD RELATIONS.

The Rt. Hon. JOHN R. CLYNES, responding to the toast, said, in connection with his knowledge of the personnel of the Gas Industry, that he knew Sir David Milne-Watson, whose name was symbolic of the fine latter-day spirit of the best type of employer. It had been his pleasure occasionally to meet Sir David at the social table, and on other occasions at a different sort of table, where they talked over the wages and conditions of the workmen; and he was sure that Sir David would agree with him that in latter

years these meetings, which partook now almost of the nature of a permanent institution, had been all to the good in the adjustment of relations between employer and employed, whether municipal authorities or private companies might be concerned. There was also present with them his old friend Mr. Will Thorne, who was now seventy-five years of age, and was as hale and hearty as he was at forty. One could not ask him to stand up as an example of the hardships of the Gas Industry. Mr. Thorne began life very early as a gas worker, and had known all the severities of the manual side of that service. Though he had not enjoyed scholastic advantages, Mr. Thorne had attained a position which assured him universal affection and respect. [Applause.] Going back to his own boyhood days, Mr. Clynes recalled the time when he had to get up and light a coal fire in the winter, prior to turning out as early as 5 o'clock in the morning. What a different state of things existed now, when one had merely to turn a tap and apply a lighted match in order to secure the same end! If, for this one thing alone, the Gas Industry had not received the blessings of the housewives of England, they were certainly entitled to them. He hoped that the cordial industrial relationships of the industry would continue. Compared with former days, the conditions of labour had improved enormously; and on the social and welfare side he rejoiced at the headway that had been made. These things were the result of the finer feeling and the more enlightened outlook between employers and employed. In these disturbed times, it would be a tragedy if any sort of industrial trouble arose in connection with any of the big industries.

Growth of the Industry and the Institution.

The only other toast was that of "The Institution of Gas Engineers," which was submitted in most cordial terms by Sir Cyril Kirkpatrick, the President of the Institution of Civil Engineers, who quoted statistics to illustrate the remarkable dimensions to which the Gas Industry has grown. It was, he said, marvellous to note what had been accomplished in the past century and a quarter. He did not think there was another industry which could show such a record in a similar period of time. It indicated what the Institution was doing, for it was mainly responsible for bringing about this great development. He congratulated the Institution on its membership, which, he understood, now approached 1500. This bore eloquent testimony to the way in which it was run. In the Institution of Civil Engineers the membership was nearly 10,000, but that embraced many branches of the profession, whereas, of course, the Institution of Gas Engineers was confined to one industry. It seemed to him that there was room for both gas and electricity. There had been cases of unfair competition in the past, but he thought a proper spirit was now getting abroad. He hoped that not only would the cordial relations existing between the two Institutions—Civils and Gas—continue, but that they would become even more cordial in the future than they had been in the past.

Unceasing Research.

The President, replying, said that the Institution was growing along with the Industry. They always felt that there was a close association between the Institution of Civil Engineers and their own Institution, inasmuch as their first President, Thomas Hawksley, was a predecessor of the proposer of that toast. To a great extent, their first President laid down the lines on which they had worked with considerable success ever since. One of the first things he impressed upon the members was the importance of research. As long ago as 1865 he suggested very much the sort of work which was now being done by the Corrosion of Pipes Committee. In 1882 the first organized research report was presented to the Institution on the "Effect of Condensation upon the Illuminating Power of Gas." Since that time the Institution had unceasingly conducted research into the problems connected with the Industry. This work was increasing in importance every day, and the greatest care was taken to ensure absolute reliability and accuracy all through. They made every step behind them sure and secure before they went on to further research.

The President went on to refer to the very happy relations existing between the Institution and the other national organizations connected with the Industry—the National Gas Council, the Federation of Gas Employers, the British Commercial Gas Association, and the Gas Companies' Protection Association. As to the Industry itself, they had all complete confidence in its future. ["Hear, hear."] They were more than holding their own, and in spite of all the financial troubles they found that gas stocks and shares were standing to-day at a higher figure than they did a year ago. This was a record which some other industries must envy.

Evening Star Lodge, No. 1719.

A Notable Gathering in Institution Week.

On Monday, June 6, the Evening Star Lodge held its Regular Meeting, which had been postponed from the fourth Wednesday in May with the object of entertaining Masonic Members of the Institution of Gas Engineers.

The Worshipful Master (W.Bro. Thomas F. C. Potterton) was in the chair and, with the able assistance of W.Bro. A. B. Potterton, I.P.M., Bro. W. H. Warren, S.W., Bro. W. F. Broadberry, J.W., W.Bro. J. W. Foreman, P.M., L.R., Chaplain, W.Bro. John A. Brentnall, P.M., D.C., W.Bro. A. L. Croager, P.M., Acting Assistant D.C., Bro. G. D. Bidwell, S.D., W.Bro. W. A. Scott, L.R., J.D., and Bro. Stephen Hay, I.G., performed the Initiation Ceremony. Earlier in the Lodge the W.M. had vacated the chair in order that the I.P.M. might conduct the ceremony of another Degree, which W.Bro. A. B. Potterton carried out with his customary efficiency. The proceedings were prefaced by an organ recital by Bro. J. Waldron Swan, Organist.

Among the many guests who honoured the Lodge by their presence were W.Bro. Fighiera, P.G.D. (who also took part in the Ceremony of Initiation), the Immediate Past-President of the Institution, W.Bro. H. E. Copp, W.Bro. James Mitchell, the Worshipful Master of the Northern Star Lodge, No. 3326, and W.Bro. W. G. S. Cranmer, the Worshipful Master of the Murdoch Lodge, No. 3480. Added interest centred round the presence of the last two mentioned brethren, since it was the first time that the Masters of the Northern Star and Murdoch Lodges had attended the Evening Star Lodge as Hon. Members. Recently the Evening Star Lodge elected as *ex-officio* Hon. Members the Worshipful Masters of the Northern Star and Murdoch Lodges during their year of office; and the compliment has been reciprocated by the Lodges in question.

Nearly 180 brethren subsequently attended the dinner in the adjoining Connaught Rooms; and the speeches were interspersed with excellent musical items under the supervision of W.Bro. Herbert Townsend, who acted as accompanist.

For the Ladies.

Once again complete arrangements were made for the ladies' enjoyment, In addition to the brilliant reception and the Sussex Tour, there were two visits specially for them, which were under the leadership of Mrs. Canning.

The first was a whole-day trip by motor coach on Wednesday to the Whipsnade Zoological Park, at Dunstable, and in this a party of about 120 (including a few of the "other sex") participated. Mr. A. C. Hovey proved to be a born "conductor," while Captain W. P. B. Beal, the Superintendent, did all he could to make the outing the success which all voted it. Luncheon and tea were taken in the Park.

On Thursday there was an afternoon inspection of the Royal Naval Museum and the Painted Hall, Greenwich, by invitation of Vice-Admiral Sir William H. D. Boyle, K.C.B., President, Royal Naval College. The party were met by the Curator of the Museum, Lieut. G. Hunt, M.B.E., R.N., and after a pleasant and profitable tour they joined members of the Institution at tea in the East Greenwich Institute of the South Metropolitan Gas Company.

THE LADIES VISIT WHIPSNADE

These impressions of a very happy outing were kindly given us by Mr. G. Braidwood, Coatbridge. Some idea of the popularity of the visit is conveyed by the size of the group.

(1) Mrs. R. M. Simpson (Denny), Mrs. G. Braidwood (Coatbridge), and Mrs. H. A. Aitken (Leven), on terra-firma. (2) The same ladies—on a higher plane, and not quite so firm. (3) Light, Heat—and Power (recumbent). (4) Mr. A. C. Hovey, on the way to the aviary, explains that, with a decent retort system, the phœnix would not have had a chance of rising from the ashes. (5) A general view of some of the party. (6) Of the party were Madame Sigurd Samzelius, wife of the Managing Engineer at Göteborg, who represented at the Meeting the President of the Swedish Gas and Water Association, and Frau Hermann Müller, wife of the Immediate Past-President of the German Association.

Visit to East Greenwich.

Thursday afternoon was devoted to a visit to the East Greenwich Station of the South Metropolitan Gas Company, where the Chemical Works and the Metro-Coalite Works were inspected, under the guidance of the Engineer (Mr. A. H. Andrews), Manager of the Chemical Works (Mr. P. Parrish), Mr. A. S. Holden, and members of the staff.

Chemical Works.

The coalite plant is described and illustrated on other pages of this issue, and some of the main features of the chemical works are also given.

A Large Tea Party.

Later, Dr. Charles Carpenter, the President of the Company, who was supported by Mr. A. Stokes and Mr. E. V. Evans, Joint Managers, received the guests at the Institute. By this time the members had been joined by the ladies who had visited the Royal Naval Museum, and the whole party, numbering about 300, sat down to tea.

Mr. Canning voiced the thanks of all present to Dr. Carpenter and the Directors of the Company for their kindness in allowing the members to inspect their fine plant, and for their generous hospitality to both the members and their ladies. Also to Messrs. Evans, Stokes, Andrews, Parrish, and Holden, and members of the staff, who had gone to great pains to make the visit both agreeable and profitable. He wished the Company continued success and prosperity, and Dr. Carpenter long life and good health.

Having acknowledged the vote, Dr. Carpenter said there was one point he would like to make quite clear. The coalite plant was not a Metro-Coalite plant, but a plant producing Metro-Coalite. Except for touches and refinements which were necessary in a case of this kind, the plant itself was in exactly the same condition as when it passed out of the contractors' hands. The Company were desirous of getting the plant going without loss of time, and they were also anxious that, if it were not a success, it should not be said that the failure had been due to the fact that the Company had tried to do something with it outside the contractors' own ideas. The plant had been put down as a large-scale experiment, because the Company thought the time had come when they ought to know something about low-temperature carbonization. To-day, thanks mainly to the coalite plant, they did know something about it. He paid tribute to the work of Mrs. Andrews and her supporters in assisting to make the afternoon a success.

Visit to Beckton

On the Wednesday afternoon a large number of members visited the Beckton Gas-Works of the Gas Light and Coke Company, at the kind invitation of the Governor and Directors.

Admirable arrangements were made for conducting the parties round the world's largest works, including a complete circuit of the works in inspection cars on the elevated railway, thus enabling the visitors to see all the points of interest, even to running out on to the pier where the coal is unloaded from the river.

The chief item of interest, of course, was the new £1,000,000 Koppers coke oven installation, which was described in detail in the "GAS JOURNAL" on the occasion of the plant being formally opened by H.R.H. the Prince of Wales on May 3. An oven was seen being discharged and the coke quenched, while the producer gas plant attracted much attention.

The water gas plant, one of the largest in Europe, also attracted much attention. It consists of nine units each with twin generators, seven of the units with mechanical generators, carburettors, and superheaters for the production of carburetted water gas. The remaining two are arranged for blue gas production. Six of the first seven are equipped with complete automatic operation, including coke charging, while all units are fitted with waste-heat boilers, and the mechanical generators are boiler jacketed. The coke is brought to the plant in standard railway wagons, which are tipped into overhead bunkers by a special wagon hoist. The coke consumption of the plant is 700 tons per 24 hours. The fan installation consists of six turbo-blowers, each supplying 1½ million c.ft. of air per hour at a pressure of 28 in. W.G.

The members were also very interested in a new plant, now nearing completion, for the extraction of benzole from 75 million c.ft. of coal gas daily by the use of active carbon. The plant will have a daily production of 20,000 gallons of benzole, and is the largest of its kind in the world. It is housed in a building 157 ft. long by 58 ft. wide by 39 ft. high, and comprises eight cylindrical horizontal absorbers, together with associated heating and cooling coils, carbon-handling plant, condensers, separators, evaporators, &c.

THE MAGNITUDE OF THE INDUSTRY.

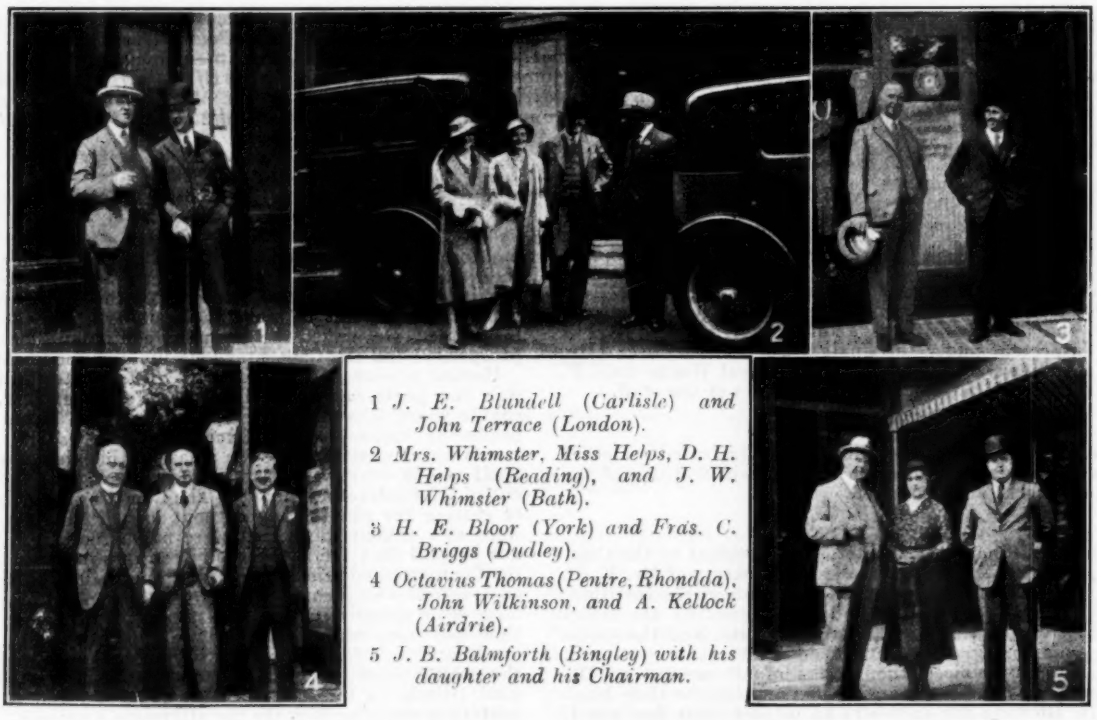
At the conclusion of the inspection, the members were entertained at tea, when the PRESIDENT (Mr. J. H. Canning) expressed the appreciation of the Institution to the Governor and Directors of the Company for their hospitality and for permitting them to visit these splendid works. The Gas Light and Coke Company, as they were aware, apart from being the biggest gas undertaking in the world, had great traditions of technical progress. Another tradition attaching to the Company was generosity in permitting those connected with the Gas Industry to see for themselves the work and technical progress being made by the Company; and his was of invaluable assistance to the Industry in general and to a great many individually. In proposing this vote, he would like to refer particularly to their friend Mr. Thomas Hardie. His enginering skill was a matter for legitimate pride of every member of the Institution, and these works were a monument to that skill. He would also like to thank Mr. R. W. Hunter (the Works Engineer at Beckton) and other members of the staff who had taken them round the works.

Before concluding, Mr. Canning said that he felt he must refer to another matter. In going round the Beckton Works, one was impressed by their magnitude, and one felt it was impossible to realize the magnitude of the Gas Industry until one had seen these magnificent works. It was a matter of gratification that His Majesty the King and H.R.H. the Prince of Wales had had the opportunity of seeing these works, and he was sure that their magnitude and technical excellence must have created an interest which would be of value to the Industry as a whole.

Mr. THOMAS HARDIE, in reply, said it would be a pleasure to convey to the Governor and Directors this vote of thanks. Sir David Milne-Watson was very sorry that another appointment prevented him from being present. They were always pleased to see the Institution, and he had no doubt they had noticed new items since they were there last. He hoped they had seen sufficient to enable them to carry away some ideas which might be of use to them on their own works.

Mr. R. W. HUNTER expressed appreciation on behalf of himself and his Staff for the kind things that had been said. They were very proud of their works and were particularly gratified to welcome there so many technical colleagues who could appreciate what was going on. They had many visitors to Beckton—over two thousand last year—but it was very satisfactory to show round the works a number of men engaged in the same Industry, who could realize their little troubles and see what they did to keep everything up-to-date.

SNAPSHOTS HERE AND THERE



1 *J. E. Blundell (Carlisle) and John Terrace (London).*

2 *Mrs. Whimster, Miss Helps, D. H. Helps (Reading), and J. W. Whimster (Bath).*

3 *H. E. Bloor (York) and Fras. C. Briggs (Dudley).*

4 *Octavius Thomas (Pentre, Rhondda), John Wilkinson, and A. Kellock (Airdrie).*

5 *J. B. Balmforth (Bingley) with his daughter and his Chairman.*

The Sussex Tour

Many people passing through Victoria Station on Friday morning may have been somewhat puzzled to see chalked up upon a notice board the words "Gas train to Battle." Perhaps they imagined it heralded the trying-out of a new system of traction. A party of some 230 persons, wearing dark red carnations, however, knew the truth, and boarded a special train drawn up at the platform indicated, preparatory to starting out upon what was to prove a glorious termination to a markedly good meeting. Of course, ideal weather conditions counted for much, but generous hospitality and faultless organization played equally important parts. The country everywhere was seen at its best, and the visitors were enabled to pick out the scenes of special interest, thanks to Miss Cicely M. Botley, who had prepared an excellent description (edited by Mr. A. M. Apel), copies of which were distributed, and which we were permitted to reproduce, with some beautiful views, in the "JOURNAL" dated June 1. The special train proceeded from Victoria to Battle, and then motor coaches to the Abbey, where there was ample opportunity to admire the beautiful grounds, bathed in that glorious sunshine to which we have become almost unaccustomed.

GUESTS OF THE HASTINGS AND ST. LEONARDS GAS COMPANY.

Then the coaches took us to the Queen's Hotel, Hastings, where we were the guests at luncheon of the Hastings and St. Leonards Gas Company, who had had the exceedingly happy idea of marking in this way the visit of the Institution of Gas Engineers as part of their own centenary celebrations. It was said that the number of guests sitting down, about 300, made up the largest luncheon party that had so far been accommodated in the hotel, but whether or not that was the case the management were fully equal to the occasion—neither fare nor service leaving anything to be desired. The chair was occupied by Mr. A. M. Apel, the Chairman of the Company, who was supported by the following Directors: Messrs. A. W. Oke, H. Burden, J. B. Lockey, J. Parsons, and H. Moppett, as well as by Mr. Botley, and the Secretary, Mr. A. E. Young. The Mayor (Councillor G. H. Ormerod), the Town Clerk, and other officials were also present.

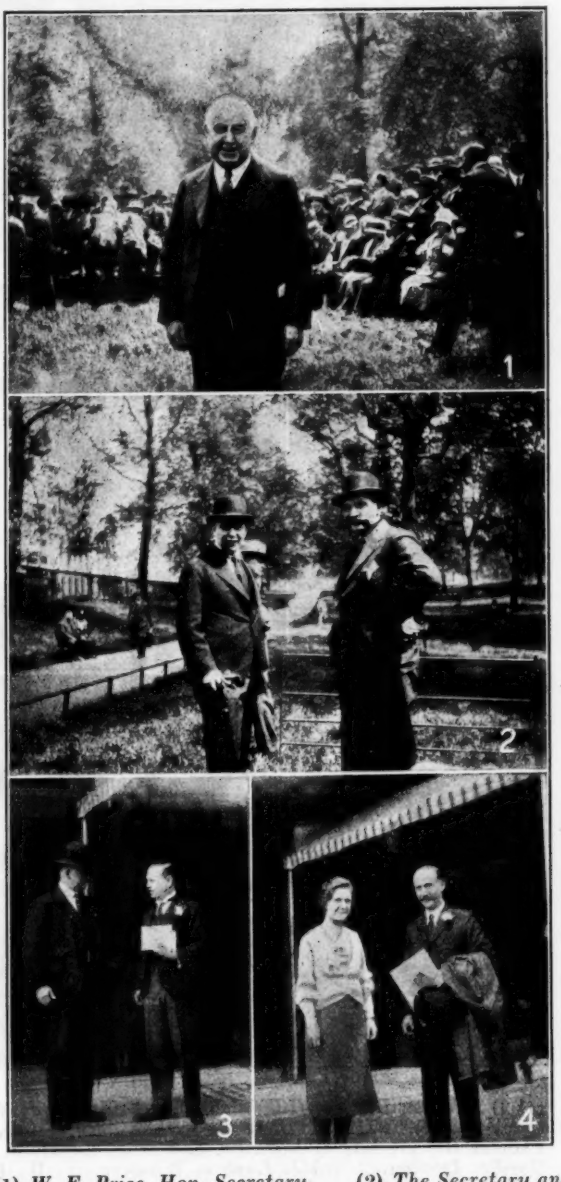
Mr. J. H. Canning, proposing the toast of "The County Borough of Hastings," pointed out that the borough was of great antiquity, possessing a historical and memorable past. But great care was taken at the same time to maintain it as one of the most modern and up-to-date watering places of the day. The Corporation did everything possible to enhance its value to visitors, and among other things he might mention the wonderful underground car park. It was also in contemplation to provide a covered promenade.

The Mayor, in replying, congratulated Mr. Botley and the Hastings and St. Leonards Gas Company on the magnificent assembly at the luncheon. The town was very proud of its Gas Company, which was most prosperous. He believed it distributed £20,000 a year among its fortunate shareholders, which was a very material blessing at the present time. ["Hear, hear."] It had occurred to him to wonder why it was that the Gas Industry was so well managed, and he had come to the conclusion that it was owing to its being managed by engineers, which was the profession to which he himself had formerly belonged. Were not the best managers of an industry those who had been brought up, not commercially, but in the rigorous training of the scientific or legal professions? Many of the blessings which were to come to our trade and industry would come via the Gas Industry.

The toast of "The Hastings and St. Leonards Gas Company" was submitted by Sir David Milne-Watson, who said he was particularly glad to be present because, owing to another engagement, he had been unable to greet the members when they visited Beckton earlier in the week. He felt quite certain that the prosperity which had attended the Hastings Gas Company throughout the past century would continue in the future; and he hoped that Great Britain and the world generally would follow on equally fortunate lines. The present was clouded, but in this country people were at their best when faced with great difficulties, and if they gave the good example of a steady head and stout heart to the rest of the world, things would brighten. They would all agree that the Hastings Gas Company owed a great deal to the wise administration of its affairs. It was fortunate in having so able a Chairman as Mr. Apel, while as to Mr. Botley no words of his could fully express his admiration of him. The name of Botley was a household word in Hastings; Mr. Botley's father was for 45 years before him Manager of these works. He need hardly remind them that Mr. Botley's connection with the Gas Industry had been long and honourable. He was a member of the Central Executive Board of the National Gas Council, and Chairman of the Effluents Committee and the Committee on Gas Charges. Thus he had devoted himself not only to the Hastings Gas Company, but to the Industry in general. The Gas Industry had a great future before it, and the Hastings undertaking itself provided an example of what could be done. Gas would have many new uses, and while it was all-important to retain the business they had, it was also essential to go out for fresh business. He did not believe there was a house or factory in any town which had not new uses for gas.

Responding, Mr. Apel heartily endorsed all that Sir David had said with regard to Mr. Botley. During the greater part of the existence of the Company the name of Botley had been associated with its management. As to the visitors, he thought that an Institution which could secure on its administrative side "Alexander the Great" and a "Pearl of Great Price" was bound to be a success. [Laughter.] The Hastings Gas Company was formed in

VOTES OF THANKS TO—



(1) *W. E. Price, Hon. Secretary.* (2) *The Secretary and C. S. Shapley, Leeds.* (3) *The President and the Secretary.* (4) *Miss Metcalfe and J. H. Winder, of the Institution Staff.*

1832—the year of the great Reform Bill. Now they had the Kettering Gas Bill, which he hoped would be only one of the steps towards the emancipation of the Gas Industry from the fetters which had prevented it from progressing so rapidly as it would otherwise have done. With Sir David, he looked forward with every confidence. He believed that the future held much in store for the Gas Industry, but he did think they would all have to keep in mind two main points—publicity and salesmanship.

To Bodiam Castle.

After lunch the drive was resumed, via Rye, to Bodiam Castle, where tea awaited us, kindly provided by Mr. and Miss Botley, who were heartily thanked for their hospitality by the President. He also acknowledged the indebtedness of the visitors to Mr. Apel, who had planned the tour. Mr. Botley replied that, for any trouble they had taken, Miss Botley, Mr. Apel, and himself had been amply rewarded by the large muster of visitors. This was the end of the centenary celebrations of the Hastings Gas Company, and he could not imagine anything more in accord with his own heart's wish than that he should be among his friends and see them enjoy themselves.

Another drive through country rich in beauty brought us to Tunbridge Wells, where the special train was waiting, and at Victoria we took leave of the President and Mrs. Canning—all of us feeling the better for a thoroughly happy day.

MORE RANDOM SNAPSHOTS

(1) W. Norris, Burgess Hill; W. Collin, Bridgend; H. Matterface, Monmouth; and A. L. Jennings, Spenborough (background). (2) J. Dickson, Kirkintilloch; G. Braidwood, Coatbridge; and A. Jamieson, Johnstone. (3) Thomas Glover, late of Norwich, and L. J. Langford, Tunbridge Wells. (4) Prof. J. W. Cobb, Leeds; and T. Hardie, London. (5) J. Lupton, Windermere; W. I. Fletcher, Grange-over-Sands; and C. F. Blincoe, Middlesbrough. (6) Dennis Wall, London; and A. W. Sumner, Ipswich. (7) H. C. Smith, Tottenham; G. M. Gill, London; W. Phillips, Luton; and W. H. Bennett, East Surrey. (8) J. W. McLusky, Glasgow; and G. P. Mitchell, Blackburn.

Presidential Address

Of J. HERBERT CANNING, O.B.E., M.Inst.Gas E., F.C.S.,

President, The Institution of Gas Engineers; Engineer and Manager, The Newport (Mon.) Gas Company

I wish, in the first place, to thank the Council and the Members of the Institution for having elected me to the Presidency. As evidence of my sincere and deep appreciation of this very great honour, it was my desire to render to the Institution and to our Industry the fullest possible service of which I was capable. Unfortunately, circumstances which were beyond my control have somewhat limited the fulfilment of my wishes in this respect, but, as far as lay in my power, I have done my best to discharge the duties of this high office.

I desire also to thank the Chairman and Directors of my Company for granting me the facilities necessary to the adequate discharge of my duties as President and the kind support they have extended to me during my year of office.

Visit to Canada and the United States of America.

The Annual General Meeting of the Institution last year constituted the First International Gas Conference and achieved a success which is full of happy augury for the future. At that meeting was initiated a new era of International co-operation which, there is every reason to hope, will be fruitful in progress both in the technical as well as in other departments of our Industry. With a view to continuing and maintaining the happy relations which were set up in June last, the Council did me the honour of asking me to represent the Institution at the American Gas Convention of the American Gas Association, which was held at Atlantic City, N.J., in October last. It was decided that I should travel to the Convention by way of Canada, in order that I might convey to the President and Members of the Canadian Gas Association the cordial greetings and good wishes of their colleagues in the British Isles. It is very pleasing to have this opportunity of expressing my grateful and sincere thanks for the unbounded kindness and hospitality extended to me both in Canada and in the United States of America.

On landing at Montreal, I was welcomed to Canadian soil by Major J. J. Humphreys, of the Montreal Light, Heat, and Power Company, who did everything to make my short stay in that City pleasant and interesting. The President of the Canadian Gas Association, Mr. Hugh McNair, of Winnipeg, made the journey of over 1000 miles to Toronto, where I was welcomed by him, Mr. Arthur Hewitt (Vice-President of the American Gas Association and of the Consumers' Gas Company of Toronto), Mr. George W. Allen (Secretary-Treasurer of the Canadian Gas Association), members of the Council of the Association, and others. Similar kindness was shown me at Atlantic City, where Mr. Clifford E. Paige, the President of the American Gas Association, Major Alexander Forward, the Managing Director, and a host of other friends did everything possible to make my all too short stay with them happy and memorable.

Progress of the Gas Industry in Canada and America.

In the face of severe competition from oil and electricity and in spite of serious trade depression, it is gratifying to find that the Gas Industry both in Canada and the United States of America is in a vigorous and prosperous condition. In the City of Montreal, one of the most conspicuous landmarks is the new waterless gasholder; 300 ft. in height and of a capacity of ten million c.ft., the erection of which has been necessitated by the rapidly increasing demand for Gas. At Ottawa and Toronto similar conditions prevail, notwithstanding the immense development of electricity in the State of Ontario, which is probably richer in water power than any industrial district of equal area in the world. At Toronto, which is supplied with electrical energy generated at Niagara, the rates for electricity for household use are probably lower than in any comparable community elsewhere. Notwithstanding this fact, the Consumers' Gas Company, of Toronto, has a remarkable record of continuous progress and prosperity. In the last ten years the number of Gas consumers at Toronto has increased from 127,000 to 170,000, the mileage of gas mains from 600 to close upon 1000, and the total sales of Gas by more than one-third. In the United States of America, in spite of the enormous extension of the use of Natural Gas, the sales of Manufactured Gas have increased from 159,000,000,000 c.ft. in 1911, to 326,900,000,000 c.ft. in 1921, and to 408,000,000,000 c.ft. in 1930.

These eminently satisfactory results have been achieved by the engineering skill and the ability, vigour, business acumen, and enthusiasm with which the problem of meeting competition has been dealt with by everyone engaged in the Gas Industry in those countries. Not only has the household load for cooking, water heating, fires, and central heating been increased, but the use of gas for Industrial purposes has been extended and developed to a remarkable degree. It is no reflection, however, upon the ability and zeal with which the Gas Industry is served in Canada and the United States of America, to point out that the absence in North America of antiquated restrictive legislation has contributed in a most material degree to their present satisfactory position. In other words, the Gas Industry there enjoys the same privileges and liberty as its competitors.

These conditions present a great contrast to those prevailing in this country, where we have too long laboured under the disadvantage imposed by Statutes, the earliest of which was framed to meet the conditions of an age when stage coaches were still running in many parts of the country and the practical application of electricity was unknown. Since that time the conditions under which Gas supply is carried on have altered completely. The non-competitive era has passed away, and has been succeeded by an age in which the keenest competition exists. Our chief competitors enjoy absolute freedom in the framing of tariffs and rates best calculated to secure various types of business, but the relatively slight modifications which have taken place in Gas Legislation since 1847 have left the position of Gas Undertakings practically unchanged. In Canada and the United States of America suppliers of gas study the economic possibilities of various fields for the use of Gas and are free to fix appropriate tariffs which will secure each type of load. The only stipulation usually laid down is that the rate shall be a just and reasonable one.

Central Heating by Gas in America.

It is customary in this country in considering the price of Gas to take into account the magnitude of the individual load, whereas, in North America, the magnitude of the aggregate load is very often the determining factor. This is particularly exemplified in the case of the great central heating load which has been built up by our Canadian and American colleagues. The individual consumption is not usually as great as in the case of certain industrial users, but the total amount of business to be obtained is very large, and on this account the rates for central heating are often lower than those applicable to industrial gas. Such a course seems warranted by the fact that the load is practically continuous for twenty-four hours each day over the whole of the winter season. It has certainly been justified by the results achieved. In New England alone the number of gas central heating installations has increased from 512 in 1925 to 6861 in

1930, the average rate charged varying from 75 cents to 95 cents per 1000 c.ft. Satisfactory as these results are, they have as yet only touched the fringe of the load, for, in 1930, even in the best developed districts, the average number of central heating installations per 1000 meters fixed was only 7·83, a small proportion in a country where central heating is so largely in use.

When one considers the possibilities of the development of such a load in this country, the question of the difference in winter temperature naturally arises. The January isotherm of 20° Fahr., crosses Canada near the Great Lakes, and no cold comparable to this is ever experienced in the British Isles. In our damp climate, however, even moderate degrees of cold are often more keenly felt than sub-zero temperatures in the clear, still atmosphere of a Canadian winter. It would certainly seem that, in this country, the best results would be achieved by the employment of a moderate degree of central heating supplemented by the gas fire, which ventilates and has a cheerful appearance. This would afford a combination of the advantages of both systems, more closely approximating to the ideal than any other method of warming houses at present in use. The question of the development of this load is well worth consideration. Both in the United States of America and Canada the opening up of these new fields for the use of Gas has been achieved by a system of constant, intensive education of the consumer, which has led to his realizing that mere fuel cost is not the only factor in the problem and that the collateral advantages are so great as to render Gas the most economical and convenient fuel both for domestic and industrial purposes.

Restrictions upon the Use of Gas.

Fair-play is a tradition of public life in this country and is being honourably upheld by the great majority of local authorities. Among recent developments in local government activity, however, there has been a growing tendency on the part of the majorities controlling the policy of certain local authorities supplying electricity, to create an extended demand for that form of energy by the simple process of prohibiting the use of Gas on all premises over which they have control. This is, of course, a gross interference with the liberty of their tenants, and they would unhesitatingly condemn similar action on the part of a private landlord. They attempt, however, to justify themselves by the dangerous assumption that conditions which, if laid down by an individual would be oppressive and unjustifiable, become perfectly seemly and just when imposed by a local authority, under the specious pretence that it is acting in the public interest. In contrast to this arbitrary abuse of power, the claim of the Gas Industry for liberty to trade is based upon our national tradition of freedom, which is admirably summarized in the following lines by Kipling:

" Ancient Right unnoticed as the breath we draw—
Leave to live by no man's leave, underneath the Law."

The spirit of antagonism to this freedom is popularly supposed to have been a perquisite of absolute monarchy and to have perished with that institution, but it is still with us and masquerades under the most unexpected disguises. The restrictions upon the use of Gas in Council houses is but one of its protean manifestations and constant vigilance will be necessary if its subtle influences are to be countered.

The Company which I have the honour to serve was compelled to oppose a Bill promoted by the Newport Corporation in 1925, and succeeded in securing the insertion of a clause which safeguarded in principle the freedom of Corporation tenants to adopt any form of light, heat, power, or energy. In spite of this pronouncement of Parliamentary opinion, however, the practice continued, and the Kettering Gas Company is to be congratulated upon its action in endeavouring to secure a reaffirmation of that decision in such a form as shall secure for all time the liberty of Corporation tenants. You have all read the debate which took place on the subject, as a result of which the opponents of the Bill did not even challenge a division, and the House of Commons, with no uncertain voice, made it clear that tyranny of this kind is equally unjustifiable whether practised by an individual or by the majority controlling a local authority. It would have been preferable, of course, if it had not been necessary for the Gas Industry to take action, but that proper feeling and a sense of fair-play should have restored ordinary liberty as a voluntary act of justice. Unfortunately, this has not been the case, in spite of the fact that ample opportunities of redress have been afforded to those responsible. It may be hoped that Parliament will now come to such a decision as shall prevent any repetition in the future of such unwarrantable interference with the personal liberty which inhabitants of these Islands have always regarded as their birthright.

Road Reinstatements.

In order to meet the rapid development of motor traffic, it has been necessary to strengthen and improve road foundations and surfaces. This has had the effect of greatly increasing the cost of the construction and maintenance of highways and consequently of imposing a tax upon gas, water, electricity, telephone, and telegraph users, with no compensating benefits. A great deal is being said at the present time respecting the advantages enjoyed by the road user at the expense of the railways, but there is here a parallel case of similar advantages secured at the expense of the general public who are served by these public utilities. This is particularly unfair in the case of our own Industry, for, as a result of the greatly increased use of Gas for heating purposes, the roads are freed of a great volume of traffic which was formerly necessary for the transport of solid fuel, while, owing to the absence of ashes, the scavenging services of the Municipalities are correspondingly relieved.

It has been estimated that two-thirds of the annual expenditure on roads is met out of local rates, and, as Gas Undertakings are almost invariably very large ratepayers, they are contributing very heavily towards the provision of facilities for the road user from which they derive little or no benefit. That the burden is no light one is shown by the fact that in some thoroughfares reinstatement charges have increased fivefold as a result of these road improvements. It is impossible to believe that the framers of the Gas Works Clauses Act of 1847 ever contemplated the position which has arisen to-day. It would certainly seem that the various public utilities should not in equity be called upon to bear such portion of the increased cost of reinstating modern road surfaces as is due to improvements carried out for the sole advantage of road users.

Coal Mines Act.

Certain provisions of the Coal Mines Act of 1930 expire in the near future, and, unless some satisfactory substitute for these can be agreed upon at an early date, there is a danger that another period of uncertainty lies before us. Few things are more likely to retard trade recovery than a recurrence of the incertitude which has paralysed our industrial progress so often since the close of the war. It is not for us to assign responsibility or blame for the disastrous stoppages of coal production in 1921 and 1926. It is certain, however, that they have not only contributed to the loss of our markets for export coal, but have inflicted damage upon our staple industries from which it is absolutely vital that they should recover if our world position as a nation is to be maintained. Only a just and lasting settlement can assist in bringing about this happy result. It is to be hoped that such a settlement will be arrived at and that with the good will of all concerned, the Coal Industry will shortly enter upon a period of permanent and increasing prosperity.

Gas Lighting.

In September last the International Illumination Congress met in Great Britain, and visited London, Glasgow, Edinburgh, Sheffield, Buxton, Birmingham, and Cambridge. It was essential, in view of the very large extent to which Gas lighting is employed in this country, that the Gas Industry should be fully and worthily represented at this important Congress. All the Central Gas Organizations took mutual action with a view to achieving this object, and their efforts were co-ordinated by this Institution, the result being that the Industry was well represented at the various meetings of the Congress, and four excellent papers, on various aspects of Gas lighting, were

amongst those presented. At the centres visited excellent examples of modern gas lighting were available for the inspection of the delegates, and pre-eminent among these was the splendid lighting of Whitehall, which will never be forgotten by those who were privileged to see it. The beautiful and artistic flood lighting of St. James' Park by means of Gas was remarkable for the admirable preservation of colour values and was a much more difficult and delicate problem than that presented by the flood lighting of buildings.

It should always be remembered that the Gas Industry has been the pioneer in the development of modern street lighting and that gas lighting is unsurpassed for its diffusiveness, reliability, and freedom from dazzle. For more than a century all the chief urban thoroughfares in this country have been effectively lighted by Gas, with a total absence of failure, and it is impossible to exaggerate the extent to which this has promoted the safety and security of life and property. In these days when the educated criminal with his lack of respect for human life, is becoming such a prominent feature of our modern civilization, it is more necessary than ever that the efforts of the Police should be reinforced by a method of lighting which is at once efficient and perfectly reliable. In addition to this, it is essential, with the great increase in motor traffic, that urban highways should be adequately and evenly illuminated without glare, and it is gratifying to find that many eminent motorists have unhesitatingly expressed a preference for Gas-lighting.

Work of the Institution.

Although the Gas Industry has been in existence well over a century, its continued growth and development necessitates an increase in the volume and importance of the research and technical work of the Institution. In order to cope with this, it has been necessary to create new Committees and to widen the scope of the work of other Committees. As the motto of the Institution implies, one of its primary functions is the undertaking of research work, by means of which constantly recurring problems and difficulties are solved and fresh avenues of technical progress are opened. The various Committees dealing with research, report to you annually at the Autumn Meeting of the Institution, which is devoted to this branch of the work of the Institution. It may be said without hesitation that the experiment made by the Institution in holding this Meeting has been entirely justified. It is now possible to give the Reports the consideration which their importance merits and to offer the criticism which is so necessary both as a stimulant and a corrective.

In addition to research and education—to which I will refer later—the ordinary work of the Institution, which is constantly increasing, has to be carried on. The efficient conduct of all these activities imposes a greater tax upon the time and energy of the members of your Council and the various Committees and Sub-Committees than is generally realized. During the past twelve months no fewer than 96 meetings of these internal bodies have been held. This is exclusive of the numerous meetings of external Committees which have to be attended by representatives of the Institution. The Industry as well as the Institution certainly owes a debt of gratitude to all who have so ungrudgingly laboured in our collective interest. Our thanks are due to the Secretary and his Staff, who have worked so whole-heartedly for the Institution and its Members and have shown such consideration and courtesy to all of us. Since the granting of the Royal Charter in 1929, the work of the Secretary has been considerably increased in the carrying out of a great deal of internal re-organization.

Recent Research.

The Street Lighting Committee has been reconstituted as the Joint Lighting Committee representative of the Central Gas Organizations. As its title implies, the remodelled Committee will deal with the whole field of Gas Lighting—public, commercial, industrial, and domestic. Although so recently established, it is prosecuting its work energetically, and will, undoubtedly, render the Industry very effective service. As a result of the depreciation in the value of by-products, the Liquor Effluents and Ammonia Sub-Committee is devoting attention to the general question of the better recovery and utilization of ammonia and its products, and will report to you in due course upon that very important subject. The Gasholder Sub-Committee has dealt with the question of gasholder inspection and insurance, and has presented a very valuable report. The remaining Research and Technical Committees and the Joint Research Committee of the Institution and Leeds University are continuing their accustomed investigations, under the direction of the General Research Committee, and useful Reports are anticipated at the Autumn Meeting. A recent and welcome development is the co-operation of the Institution with the research departments of the larger Gas Undertakings and of private laboratories. Most valuable assistance has already been rendered, and our thanks are due to all who have co-operated so cordially in this important work.

Education.

The Education Committee has continued its difficult, but vitally indispensable work, with such success that the number of entrants for the Examinations of the Institution this year shewed an increase of over 56 per cent., as compared with last year. In the nature of things it will take some time before the labours of this Committee bear their full fruit. They have tilled the ground assiduously, but the harvest will undoubtedly exceed the most sanguine expectations of those who have initiated and conducted this great work. Although engineering as applied to military purposes is a very ancient profession, its application to the problems of transport and industry dates only from the great industrial development of the eighteenth and early nineteenth century. It was inevitable, therefore, that the early engineers should be recruited from the ranks, and this fact, combined with their lack of general education, delayed due recognition of their great ability and the invaluable services they rendered to the Nation. The great Brindley, whose canals were the source of immense wealth to less deserving men, was scarcely able to read and write, and, largely as a result of this, his services were shamefully undervalued by those for whom he worked. On the other hand, Telford, who was of equally humble origin, received an elementary education sufficiently sound to form the foundation of a course of self-study, which was actively prosecuted by him during the greater portion of his career. He acquired a knowledge of Latin, French, and German, occasionally even indulged in the writing of verse, and his company was sought by some of the most distinguished literary men of his time. These varied acquirements in no way interfered with his activity and ability as an engineer, and he undoubtedly advanced the prestige of the profession in a manner that Brindley, his equal in all but education, could never have accomplished.

In providing for the training of those upon whom will devolve in the future the vital task of the technical guidance of the Industry, the Institution has assumed a great responsibility. It may be confidently stated that on the lines laid down, an intelligent and industrious aspirant will attain a standard both of general and specialized education which will admirably fit him for the tasks which await him in the future. It is vital, however, that the right type of candidate should present himself, and the responsibility for securing this, which does not rest with the Institution, is a very real and serious one, as our future success depends upon the maintenance of the proper standard. One cannot build up a first class organization with second class brains, and it is essential to the continued prosperity of our Industry, that young men of the requisite character and intelligence should be attracted to its service. It will be sufficient to add that, if the prospective rewards of a Gas Engineering Career are sufficient, the right type of candidate will not be lacking. In the case of most Undertakings this is fully realized and acted upon, but, until such action becomes universal, the full possibilities of the Industry will not be developed.

Conclusion.

The Institution, acting as the authority upon the technical aspects of the numerous problems to be confronted, has maintained its customary friendly and hearty co-operation with all the organizations which are so ably

working for the furtherance of the interests of our Industry. The period through which we are now passing presents its own special difficulties, but, when they are surmounted, as they will be surmounted with the good-will of all concerned, it may certainly be anticipated that a new era of increased development and prosperity lies before the Gas Industry. There is every reason for confident assurance that this will be the case. The Nation has just passed through a crisis more serious in many respects than that with which it was confronted in the Great War. We were compelled to abandon the Gold Standard, and heroic measures were necessary for the restoration of the Nation's credit. These have been willingly and even cheerfully accepted by the country with the self-sacrifice and dogged resolution which are still characteristic of our people. As a result, although there is much yet to be accomplished, our national credit has been maintained, and we may confidently look forward to a gradual restoration of trade and industry. In the meantime the financial security of many other countries has trembled in the balance, great financial interests have foundered in the storm, and far too many of our staple industries have, wholly or partially, lost their profit-earning capacity.

It is gratifying, however, to record that the Gas Industry has not only survived this unexampled economic tempest and trade depression but has fully upheld its position, and, even at a moment when Government securities were severely affected by world wide uncertainty and apprehension, the stocks and shares of Gas Companies maintained their value in a manner unsurpassed by the securities of any other trade or industry. We all share the confident hope that the darkest hour of depression is over and that we may shortly expect the serene dawn of prosperity. In that returning prosperity our Industry will undoubtedly participate, but we must have complete freedom to trade, unfettered by unfair or illegal restrictions. In this connection it may be said that a healthy public opinion is asserting itself and there is a better realization both of the services which Gas is rendering to the community at the present time and the possibilities of extending these in the future. One of the primary aims of the National Government will undoubtedly be the restoration of our industries, and it is to be hoped that this change in public sentiment towards Gas, acting through the will of Parliament, will shortly strike off the shackles of antiquated legislation which have so long impeded our progress, and enable us to render to the community that fuller and more efficient service which we have hitherto been debarred from giving.

New Members of the Institution

On Tuesday, June 7, the following were elected to Honorary Membership, Membership, Associate Membership, and Associateship of the Institution:

Honorary Membership.

The Presidents (*ex officio*) of the Union Internationale de l'Industrie du Gaz and of the Gas Associations of America, Australia, Austria, Belgium, Canada, Czechoslovakia, Denmark, France, Germany, Holland, Hungary, Italy, Japan, New Zealand, Norway, Poland, Spain, Sweden, Switzerland, and Yugoslavia.

Membership.

Aldridge, Herbert James Turner, Acting Managing Director, Aldridge & Ranken, Ltd., Avonbank Works, Bath, Somerset.

Carr, Ralph, Director, Davison & Partner, Ltd., 11, Carteret Street, S.W. 1.

Fletcher, William Ivory, Secretary, Engineer, and Manager, Grange and Cartmel District Gas Company, Grange-over-Sands, Lancashire.

Glover, Thomas Bernard, M.Sc., Works Engineer and Chief Assistant, the Primitiva Gas Company of Buenos Aires, South America.

Goodwin, Frederick Harold Gregson, B.Sc. (Eng.), Assistant Engineer, Corporation Gas Department, Salford, Lancashire.

Langford, Cecil George, General Manager, George Glover & Co., Ltd., Ranelagh Works, Chelsea, S.W. 3.

Pride, William James, General Manager and Managing Director, Blandford Gas Company, Ltd., Dorset.

Thornton, Horace Moore, Chairman and Managing Director, Richmonds Gas Stove and Meter Company, Ltd., 164, Queen Victoria Street, E.C. 4.

Tilley, Frederick Charles, Chairman, Peebles & Co., Ltd., Tay Works, Bonnington, Edinburgh.

Associate Membership.

Anderson, Alexander Ross, Engineering Assistant, Vale of Leven Gas Company, Ltd., Alexandria, Dumbartonshire.

Canning, Thomas Herbert, Junior Assistant Engineer and Manager, Southend-on-Sea Station of the Gas Light and Coke Company.

Cowley, Leonard Reginald, Works Superintendent and Senior Assistant to Engineer and Manager, Urban District Council Gas Department, Shipley.

De Gruchy, Roy Thornton, B.Sc., Engineering Assistant, Beckton Station of the Gas Light and Coke Company, London.

Dobson, Arthur, Director, Manager, and Secretary, F. C. Sugden & Co., Ltd., 10, East Parade, Leeds.

Garner, Leonard Francis, Higher Technical Assistant, Luton Gas Company, Bedfordshire.

Greaves, Ralph Lincoln, *Institution Diplomé in Gas Engineering, 2nd Class*, 1930. Assistant Works Superintendent, Wolverhampton Gas Company.

Greenwood, Leonard, Assistant Engineer and Manager, Leatherhead Gas Company, Surrey.

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The Co-ordination of Power Relative to Gas-Works

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INTRODUCTION.

The application of power-worked appliances to the Gas Industry was of relatively slow growth during the last century, being mainly confined to exhausting plant, pumping machinery, and cranes for unloading coal. Power was transmitted by steam, fuel was cheap and the system at that time was satisfactory, being simple, reliable, and flexible.

The introduction of power-operated machines for charging and discharging retorts, and the mechanical handling of coal and coke in retort houses, produced a demand for a means of transmission of power, the efficiency of which was not dependent upon a considerable temperature difference between the transmitting medium and the ambient atmosphere. This was met by the rope drive and the pneumatic and hydraulic systems, of which the first, being cumbersome, was used only to a limited extent. The latter two systems have been ousted gradually by electric transmission because of its much higher efficiency, although they still have compensating advantages for certain purposes, such as when it is desired to produce a short and definite reciprocating movement limited to a predetermined force or a rotary motion of defined and limited torque.

During the present century and more especially during the last fifteen years, plant has become available to enable great economies to be effected in three directions:

(*a*) The mechanical handling of bulk materials.

(*b*) The highly efficient and reliable transmission of power by electrical energy.

(*c*) The production of steam at low cost.

These have reacted on one another inasmuch as material handling plants require a form of power capable of producing cheaply and cleanly a rotary motion preferably lending itself to distant control of such a character that complicated sequences of operations can be performed by attendants without fear of error. Electrical energy is the only form of power transmission which meets such requirements.

For the production of such energy, the steam driven prime mover has many advantages, more especially when the necessary supply of steam is produced at low cost; and such supplies of steam are to-day available in the larger works from two sources:

(1) From heat which is surplus and cannot be utilized economically in the various gas manufacturing processes.

(2) From low grade cheap fuel—*i.e.*, breeze.

I. GENERAL PRINCIPLES.

The power requirements of Gas Works vary for many reasons, depending on whether the coal supplies are delivered by water or rail, the class of carbonizing plant in use, the amount of gas and water pumping necessary, and to some extent the compactness or otherwise of the layout of the various items of the plant.

Where the coal supplies are water borne, coal unloading appliances are provided—usually in the form of grabbing cranes or telphers of high capacity to ensure rapid despatch of vessels. Considerable power is required for this operation, and it may be necessary also to bring the coal considerable distances by means of conveyors from the berth to the retort houses or storage ground.

Provision in such cases, moreover, must be made for the supply of such power over and above the peak load of the other requirements of the works, as the times of unloading are generally regulated by the tides and may occur at any period during the twenty-four hours.

On works where the coal is rail borne, the power requirements are small, being confined to the operation of tipplers and capstans, such work being usually carried out at stated times during the day.

Retort charging and discharging machines are now mainly electrically operated. The work may occupy a period up to 70 minutes, and, in the larger works, may recur at intervals of two hours.

The coke handling plant is worked at the same time and in conjunction with the discharging machines.

Exhausting plant, which is continuous in operation, requires an extremely flexible drive free from sudden interruptions and is usually steam driven on all large Works.

Gas pumping has similar requirements, but the work is generally of a more intermittent character.

Pumping other than for gas is partly intermittent and partly continuous, the following liquids being handled:

(1) Water for boiler feed.

(2) Water for cooling, quenching and other trade purposes.

(3) Ammoniacal liquor.

(4) Tar.

Water is now most conveniently handled by means of centrifugal pumps which lend themselves particularly to electric drive, but, where absolute reliability is essential such as for boiler feeding, steam is preferable, and with the comparatively small quantities handled for this purpose in most Gas Works, the direct acting type of pump is the most suitable.

Ammoniacal liquor and tar are best handled by means of positive reciprocating pumps, and these are generally driven by steam, although the use of electric motors for this purpose is now becoming common where sudden interruptions to the current supply do not inconvenience the production of gas.

Gas washers of the rotary type are generally driven by small non-condensing steam engines; the load factor is high, the machines operating continuously. In certain cases the more modern plants are being electrically driven.

In addition, power is required for many miscellaneous purposes such as repair shops and work of a similar character which constitutes a steady day load.

II. POWER GENERATION.

(i) Fuel Fired Boilers.

Lancashire boilers are those most generally used in the smaller Works. They are undoubtedly the most reliable type, having no mechanical auxiliaries liable to disarrangement. They are generally hand fired and there are available many furnaces specially adapted for burning breeze. This class of boiler, however, has a limited evaporative capacity, and for this reason water tube boilers have for some years been installed in preference, particularly in the larger works of the country.

The original installations of the water tube type of boiler were hand fired, but more modern installations are fitted with mechanical grates, economisers, superheaters, and balanced draught. Settings are now available which allow fine breeze to be economically burnt at high rates of combustion, while the excellent design of grit and dust arresters has entirely overcome the nuisance of the emission of such products from the chimney.

Steam pressures have gradually risen from about 60 lbs. per sq. in. to about 160 lbs. per sq. in., the latter meeting all requirements for normal services except in very large works where boilers designed for pressures up to 300 lbs. per sq. in. have been installed to meet special requirements.

Direct-fired boilers are necessary even when the whole or the greater part of the steam requirements is raised

by waste heat. The waste heat boiler is essentially a base load installation and fuel-fired boilers should be available to meet either sudden demands for steam, or the normal requirements in the event of a waste heat boiler being put out of action for cleaning or repairs.

(ii) Waste Heat Boilers.

The waste heat boilers installed in retort houses are now mainly of the cylindrical multitubular fire tube type, as this design generally lends itself more readily to being installed in a restricted space than does the water tube variety.

They are fitted with power driven draught fans which should be steam rather than electrically driven, as the latter medium is always liable to interruption of supply. In addition, if the exhaust steam can be utilized to heat the incoming feed water, a high overall efficiency can be obtained when air infiltration can be maintained at a low level, as the load on the fan will be such that the whole of the heat of the exhaust can then be absorbed.

Automatic feed water regulators are always fitted. These generally operate by checking partly or wholly the entry of water into the boiler. Such an arrangement is satisfactory where a number of boilers are being fed from a common source, so that one or another of the boilers will always be taking water from the feed line; but batteries of waste heat boilers seldom exceed three in number in a Gas Works and, at times, the feed is entirely cut off from all the boilers simultaneously, resulting in the feed pumps having to work against a relief valve set somewhat above the highest pressure required. Relief valves for such a duty, if constantly worked, soon leak, while the choking of the pumps tends to wear the buckets and barrels.

The layout of a waste heat boiler plant shown on Figure 1 overcomes this difficulty and has proved in practice to be highly satisfactory. It will be noted that the equipment forms a complete unit of one feed pump and feed heater for each boiler, as it has been found that the modern feed pump is most reliable and will run without attention between the periods when the boiler is shut down for examination. The feed heater is generously proportioned so that it will also operate efficiently for a similar period without cleaning.

It would not, however, be advisable to work without some standby source of feed, so each feed pump is of sufficient capacity to supply water to two boilers through an emergency connecting main. The large capacity of the feed pump enables it to operate for its normal duty at a low speed which is conducive to long life and low maintenance costs.

This arrangement of one pump to each boiler allows the speed of the pump to be controlled automatically so that the relief valves do not come into action except in case of emergency. The arrangement, however, necessitates the feed being controlled by hand during such time as two boilers are being fed from a single pump. This causes no inconvenience in practice as the occasion only arises at long intervals and then but for a short duration to allow of some slight adjustment. It will be noted that the layout is very simple and a minimum number of valves are employed.

Most waste heat boilers are provided with superheaters and constant attention should be given to the degree of superheat attained. The superheaters for this class of boiler have to be installed in the incoming flues, where the temperature conditions at times may be considerably higher than those provided for in the original design. They can be shielded to some extent by being placed in such a position that they are out of the direct path of the gases.

When chemically softened water is used for feed purposes, there is always a tendency to prime with this class of boiler. Priming results in water being carried over with the steam into the superheater where it evaporates and causes a deposit of scale, which, if not checked, will in time lead to a complete stoppage of the tubes. It is advantageous to make provision for sight-holes in the walls of the flues—so situated that an unobstructed view can be obtained of all the superheater tubes in order that the change of colour of any tube in which a deposit is forming can be seen and the trouble anticipated and rectified before damage takes place.

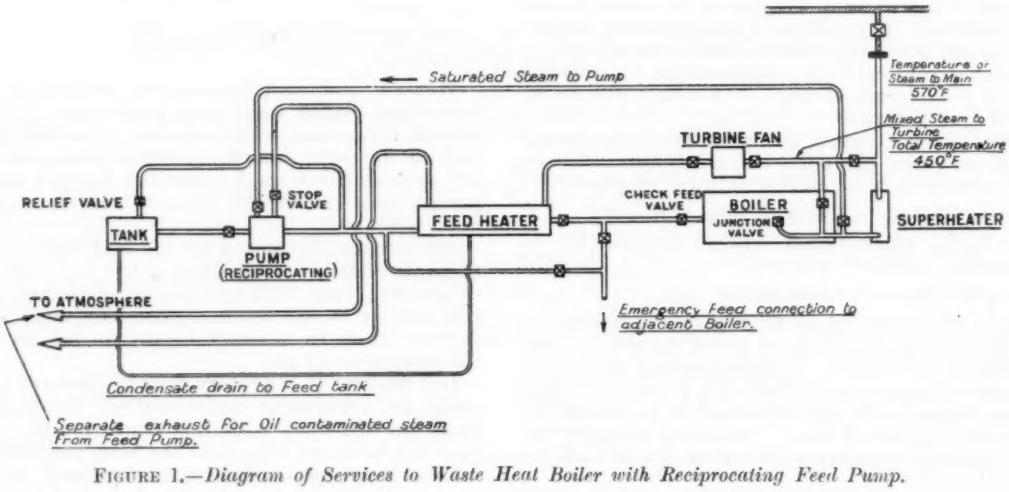

Figure 1.—*Diagram of Services to Waste Heat Boiler with Reciprocating Feed Pump.*

Superheaters placed in a horizontal position so that they naturally drain to the outlet, are less liable to be stopped up than those placed vertically.

Boilers working on horizontal retort settings seldom prime sufficiently to cause inconvenience in operating, but with continuous vertical retort settings, considerable difficulty may be experienced, due to the higher temperature of the waste gases.

The rate of evaporation is exceedingly high at the inlet end of the boiler—approximately 50 per cent. of the evaporation takes place in the first 25 per cent. of its length. This in itself does not cause priming provided the boiler is fed with condensed steam or other perfectly pure water which seldom is obtainable in a Gas Works. The high rate of evaporation in combination with chemically softened water may produce priming sufficiently severe to result in a complete loss of superheat. The heating surface per foot length of boiler therefore becomes an important factor, when related to the diameter.

Priming can be wholly or partly rectified by blowing down so that the concentration of salts in the water in the boiler is kept within defined limits, the most suitable limits being obtained by trial so as to avoid waste of water.

Where the conditions on existing boilers are particularly onerous, it would appear that the only certain remedy

is the provision of an auxiliary drum between the boiler and the superheater, of sufficient capacity to ensure the complete separation of water so as to allow of its removal by means of steam traps.

The Author would like to suggest that there should be a standard method of rating this class of boiler. It may not be generally realized that the heating surface of the tubes are calculated by some makers on the water side and by others on the fire side, so that a comparison of heating surfaces of boilers of different makes may be misleading.

Waste heat boilers used in connection with carburetted water gas plants are generally of the well-known inclined cylindrical multitubular upright type with a separate steam drum. These are seldom fitted with superheaters. This class of boiler is not usually fitted with automatic devices for feed regulation as the gas-making attendant is generally responsible for this duty. Certain of the larger automatic plants, however, have been provided with such appliances which have proved quite successful. The water level does not remain constant, but is restrained to a definite rise and fall; the level rises during periods of steaming and falls during gas-making, the amplitude of the movement depending upon the duty the boiler is performing.

Waste heat annular generator boilers are generally of considerable diameter, and it is difficult to ensure that the internal walls form an absolutely true circle. This part of the boiler is subjected to compressive stresses and the plates are therefore made of considerable thickness and the steam pressures are kept low—usually about 35 lbs. per sq. in. For this reason steam from this source is only suitable for process work. This class of boiler is simple in design and recent improvements have obviated some slight difficulties experienced in the earlier designs where rivet leakage was at times experienced in the event of the hot zone of the fire being allowed to become above or below its correct position.

III. DIRECT USE OF STEAM.

(i) Process Steam.

Process steam is required in Gas Works for the following purposes:

The manufacture of water gas.
Steaming retorts.
Steaming producers.
The production of benzole.
The manufacture of sulphate of ammonia.
Heating gas prior to purification.
Gas drying.
Miscellaneous heating purposes.

Most of such process steam is required at low pressure and the use of back pressure or pass-out turbines enables useful work to be performed in a highly efficient manner, resulting in considerable financial savings.

As examples of combining power production and process work in the various Works of the Gas Light and Coke Company, the following may be quoted:

(*a*) Back pressure turbine driven waste heat boiler fans and steaming vertical chamber ovens.
(*b*) Back pressure and pass-out turbo-boosters pumping gas and the production of benzole.
(*c*) Back pressure turbo-generators producing electricity and the production of sulphate of ammonia.
(*d*) Back pressure turbine driven pumps and the drying of gas.
(*e*) Back pressure engines and turbines heating gas, water, and buildings.

The use of exhaust steam has not been adopted for water gas plants and mechanical producers, because the development of the mechanical grate has introduced the water jacketed generator, from which sufficient steam is available to meet the process demands for this type of plant.

(ii) Steam for Power Production.

The use of steam is preferable on the score of reliability and flexibility for operating directly the following plant:

(1) Exhausters.
(2) Gas pumps and boosters.
(3) Waste heat boiler draught fans.
(4) Boiler feed pumps.
(5) Pumping or other services, the sudden interruption of which would inconvenience gas-making.

Steam is also the most economical means of providing power for any service which can be combined with a process requiring a sufficient supply of low pressure steam to absorb the whole or major portion of the exhaust. In addition when the cost of steam is low, it provides the most economical and convenient means of generating electricity.

Steam can be converted into power by two forms of prime mover, the reciprocating engine and the turbine. The reciprocating engine is limited to comparatively low speeds, but is considerably more economical than a turbine when run non-condensing. The turbine, on the other hand, has certain compensating advantages for a number of purposes.

(*a*) It is essentially a high speed machine eminently suitable for driving fans, blowers, centrifugal pumps, and electric generators.
(*b*) It occupies a very small space resulting in a low capital cost in buildings and foundations.
(*c*) The exhaust steam is uncontaminated with lubricating oil, a particularly valuable feature where the conservation of condensate is desirable, as in districts where there is no source of naturally pure water for boiler feeding purposes.

The economy of steam is considerable when exhausting to vacuum, so that a condenser should be provided wherever possible. In order to avoid excessive capital costs, a single condenser may be arranged to deal with the exhaust from several turbines.

In most Gas Works there are certain essential pumping services where the pressure volume ratio or the character of the fluid pumped necessitates the use of reciprocating pumps. For such purposes the single line direct acting type is more economical than the duplex, more especially if arranged with a long stroke, say 24 in., the clearance losses then being at a minimum. The steam consumption of this type of prime mover is higher than any other as it works without expansion of the steam. The actual power requirements are, however, generally low, so that the total consumption need not be excessive if the plant is carefully adjusted and maintained.

For the generation of electricity, the high speed compound reciprocating engine is most economical for powers below 250 kw., but for powers above, the turbine is now generally used.

IV. GAS ENGINES AS PRIME MOVERS.

Where what may be termed bye-product steam is not available at low cost, gas engines have certain advantages. Thus in isolated situations where gas boosting is only required for short periods daily, they offer an economical solution of the power problem. In addition, if the individual units are relatively small, so that more than one is always in action, they are more reliable than electric motors taking current from an outside source, which is always liable to interruption of supply.

This class of prime mover is also frequently of use for standby electric generating plant, as it can be quickly brought into service in the event of any failure of the main plant.

V. TRANSMITTED POWER.

(i) Compressed Air.

The use of compressed air for transmitting power on Gas Works is now mainly confined to that required for portable tools and for pumping water from artesian boreholes. It was originally introduced into the Industry for

the purpose of operating retort charging and discharging machines, a few examples of which are still in use. The overall efficiency of this form of transmission is relatively low, and it is now only used on the score of expediency for purposes where the advantage of its extreme flexibility outweighs its high operating cost, or where the risk of fire or explosion does not permit the use of electricity.

When used for pumping water, the power consumption is approximately twice that required by centrifugal pumps for the same duty. This is offset, however, by the extreme simplicity of the apparatus required below the ground level, the ease with which it can be withdrawn for examination and repair and the absence of foot valves or other working parts in the borehole.

An example of a special application of compressed air is that of the operating gear of the doors on the main coal bunker at the Beckton works of the Gas Light and Coke Company. These doors, 96 in number, are opened and closed in groups of sixteen by means of compressed air cylinders. This medium was selected as being free from the possibility of freezing and to ensure that no damage would be sustained by the doors or gear in the event of the apparatus becoming jammed by foreign matter in the coal. Approximately seven million tons of coal have been dealt with through these doors without any breakdowns being experienced.

(ii) Hydraulic Power.

Hydraulic power was first introduced into the Gas Industry for use with cranes, but was also applied to retort charging and discharging machines. For this purpose its efficiency is somewhat higher than that of compressed air, but it requires special conduits or pipes to deal with the exhaust water. It has now been superseded for these purposes by electricity in most Gas Works.

Notwithstanding the high efficiency of electricity, hydraulic power is still frequently used for operating wharf and other stationary or semi-portable cranes. It is capable of withstanding the roughest usage and is smooth and certain in action. It is difficult to justify the substitution of electric for existing hydraulic cranes on the score of economy, but new plant is generally now installed of the former type where a supply of current is available.

The definite force exerted by a hydraulic cylinder makes this method of operation particularly useful for purposes such as the opening and closing of the doors of intermittent vertical chamber ovens and the various valves of carburetted water gas plants.

(iii) Steam.

The concentration of steam-using plant is always difficult and generally impossible in Gas Works. Steam, therefore, has of necessity to be used as a transmitting medium. When the steam mains are carefully designed and maintained, the efficiency is relatively high. A steam transmission system suffers from the defect that its losses are nearly constant and do not depend entirely upon the load.

The use of superheated steam is strongly recommended. If the mains are so proportioned that the velocity of the steam is kept as high as possible without resulting in excessive loss of pressure, it can be transmitted for considerable distances before becoming saturated, and with a minimum loss by water being discharged from the steam traps. With this end in view, it is essential that the insulation of the mains is of a high order, that the insulating material is of best quality, of ample thickness, and carefully protected from accidental damage. All flanges and valves should be covered. Superheat results in increased economy in the prime movers and obviates the nuisance of condensation in reciprocating engine cylinders.

(iv) Electricity.

It is hardly necessary to state that electrical energy provides the most efficient transmission system yet available. When originally introduced into Gas Works, direct current at about 220 volts was most generally used. Since the standardization of frequency, there has been a tendency to adopt three-phase alternating current for new installations so as to conform with future standard equipment.

The relative advantages of the two systems may be summed up as follows:

Direct current is simple in application and the Home Office regulations for voltages of 220 or under are the least stringent. It is the safest form of current for use in bare conductors for overhead trolley equipment. Variable speed motors are simple and inexpensive, though incidentally, the advantage of this characteristic is frequently exaggerated as there are few services which definitely require this type of motor.

Alternating current has the advantage that the voltage can be easily and efficiently raised or lowered by static transformers. These require no attention and enable the current to be generated at high voltage so that large powers can be transmitted considerable distances at low capital cost for cables. The voltage can easily be stepped down to any pressure where required for use. Alternating current motors are simple, robust, and somewhat cheaper than those for use with direct current. Static rectifiers are now available which will convert to direct current.

Electrical equipment for use in Gas Works should be of robust design, as many of the services are particularly severe, the plant being subjected to coke and coal dust, steam, and other fumes. The Gas Light and Coke Company have for some years insisted on special attention being paid to the protection against dust and fumes, and plant is now available which will operate for long periods with a minimum of attention.

Electrical energy for the transmission of power differs particularly in one respect from compressed air and hydraulic pressure inasmuch as the latter systems are liable to constant losses by leakage. When leakage occurs between the pressure side and the atmosphere, it can be readily discovered, but losses of pressure past valves and pistons may continue unsuspected for considerable periods. Any equivalent dissipation of electrical energy is easily detected as it makes itself apparent by bringing the protective devices into action.

This characteristic of electrical energy, whilst being conducive to high overall efficiency, makes this method of power transmission liable to sudden interruption, a point which has been stressed previously in the paper. Such interruptions are seldom of long duration, but the liability exists and cannot be ignored when considering the purposes for which any particular motive power is required.

The power absorption of plant driven by electric motors is easily ascertained and total power consumption is cheaply and accurately metered.

VI. THE APPLICATIONS OF ELECTRICITY.

The following plant is particularly suitable for being driven electrically:

Cranes.
Coal conveyors.
Coal crushers.
Retort charging and discharging machinery.
Coke conveying, cutting, and screening plant.
Rotary washers.
Pumps—centrifugal and reciprocating.
Oxide handling and disintegrating plants.
Lifts.
Machine tools.

Apart from the fuel economies effected thereby, there is frequently a saving in operating labour costs due to the greater convenience of this form of motive power. For example, the coal crushing and handling plant in connection with the coke ovens at Beckton employs electric motors. The whole of the contactor starters are concentrated on a single open type board installed in a special dust-tight room. The plant is started by pressing a button near the discharge of the final conveyor into the overhead coal bunker. A second button stops the feed of coal, the remainder of the plant continuing in action until the conveyors are cleared, when the whole plant automatically stops. Emergency buttons are placed at various points, any one of which will instantly stop all the machinery. Certain items are in duplicate and these can be put in or out of action by simple switches on the main board.

In addition, there are several special purposes for which electricity is used, such as de-tarring by minute currents

up to 50,000 volts pressure, signalling on works railways, signalling between retort houses and exhauster houses, and the distant operation of recording devices.

VII. THE APPLICATION OF POWER AT WORKS OF THE GAS LIGHT AND COKE COMPANY.

Almost the whole of the power used in the 15 Works of the Gas Light and Coke Company is now produced by steam, either direct or by conversion into electrical energy. Nearly 2 million tons of water are evaporated yearly, 68 per cent. of which is by the utilization of waste heat and 14¾ million units of electricity are generated annually.

The following descriptions of the power plants of four of the Works of the Company are selected as typical examples of the latest practice in dealing with the problems met with in conjunction with horizontal, coke oven, intermittent chamber ovens and continuous vertical carbonizing plant, together with that of the Products Works.

(i) Beckton.

Steam System.

The original layout of the steam raising plant at this Station consisted of several isolated boiler houses each supplying steam to a group of engines, pumps, &c., the boilers being of the Lancashire type.

The reconstruction of the water gas plant, started in 1911, included a battery of eight water tube boilers, each having a capacity of 10,500 lbs. of steam per hour at 130 lbs. per sq. in. pressure. The furnaces were provided with forced draught for burning rough breeze fuel, and the firing was carried out by hand. The remainder of the boilers in the Works were also arranged to burn breeze fuel.

During the period of the War and immediately afterwards, the output of the Station increased rapidly, and owing to the difficulties of that period, sufficient corresponding addition to boiler plant was not possible. In order to meet the increased demands for steam, it became necessary to use a considerable quantity of coke as boiler fuel.

Directly circumstances permitted, rapid extensions to the boiler plant were undertaken, and a scheme was prepared and carried out whereby with the exception of one of the original boiler houses the whole system was interconnected and controlled from one point.

A general layout of the steam system is shown in Figure 2.

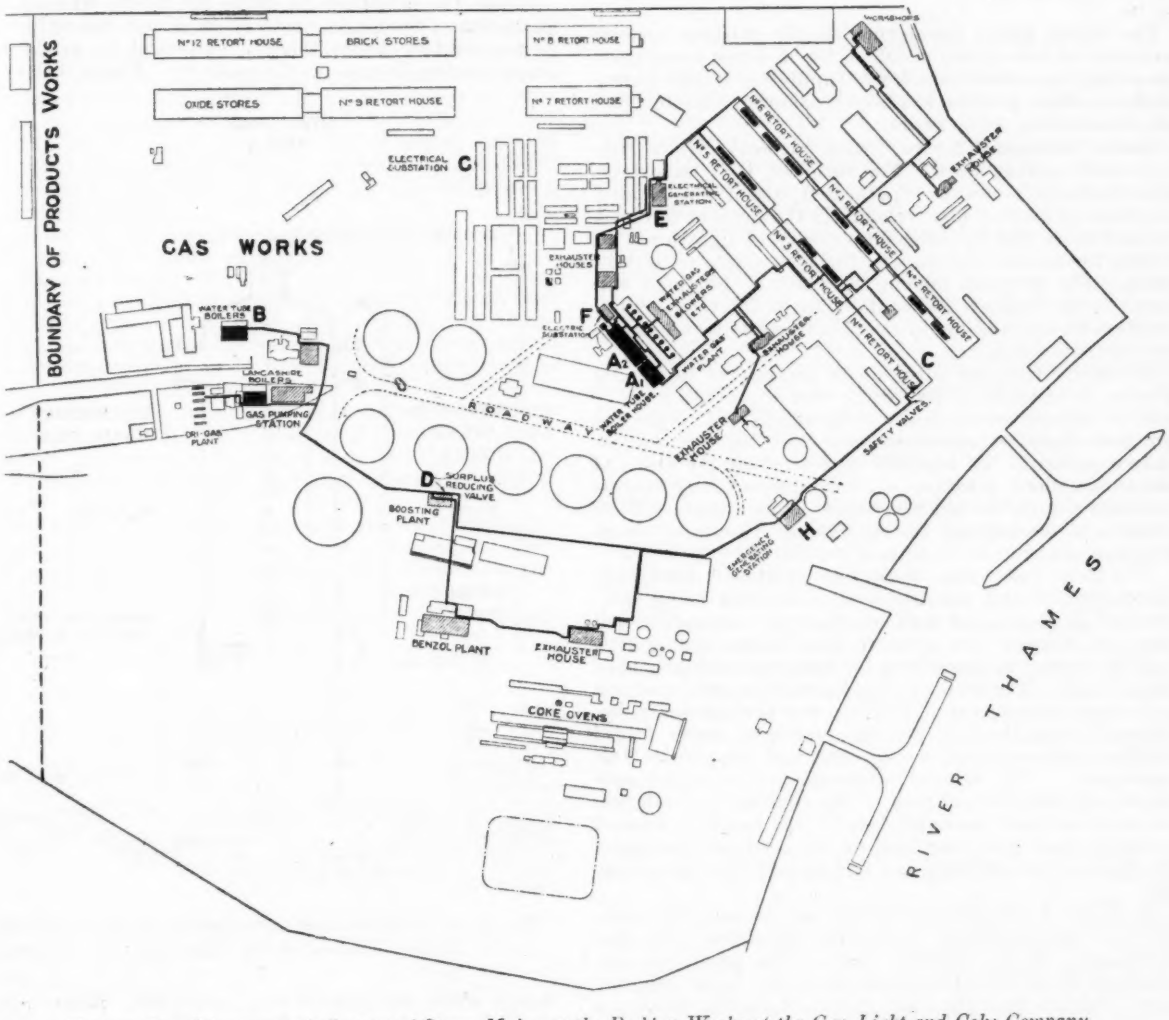

Figure 2.—*Diagrammatic Layout of Steam Mains at the Beckton Works of the Gas Light and Coke Company.*

Eleven waste heat boilers in five of the retort houses are interconnected with four water tube mechanically fired boilers at the position A_1, the system working at 160 lbs. per sq. in. superheated to 300° C. Nine waste heat boilers in the water gas plant are interconnected with the eight original water tube boilers at the position A_2, this system working at 130 lbs. per sq. in. dry saturated. The two systems are linked together and operated as one by means of surplus reducing valves also situated at the position A_2.

With the building of coke ovens, the activated carbon benzole plant and the drying of gas, additional steam raising plant became necessary, and as it was not possible to extend further the installation at the position A, the building of a plant of the latest type was planned at the position B. This position is in close proximity to the

only remaining battery of Lancashire boilers which had been retained when the previous reconstruction had been carried out.

The main consideration for the retention of the boilers was the desirability of retaining a steam raising plant in immediate proximity to the main gas pumping engine room. This gas pumping plant is the most important of the Company, and it was realized that if and when it becomes necessary to increase the quantity of gas delivered through the twin 48 in. mains to London, increases in gas pressure and therefore in steam requirements would result. It was therefore decided that the most suitable position for a new Boiler Plant was at the position B.

To take advantage of the economies which can be effected by modern steam equipment, the boilers were designed for a pressure of 300 lbs. per sq. in., although for the time being they will only be worked at 250 lbs. per sq. in.

The steam mains connecting to the existing system presented an interesting problem, the distance being considerable over a route which will supply the requirements of plants whose position has been fixed other than by consideration of the steam supply.

Steam is required for two main purposes, use in turbines and process work. For turbines, it is important that the steam is always superheated, and it was decided therefore to adopt a high velocity in the main at full load so that there will be sufficient velocity at light loads to ensure the steam reaching the turbines above saturation point. The pressure loss in the main at full load will result in the steam reaching the point of interconnection, position C, with the 160 lbs. per sq. in. system at approximately that pressure.

To ensure that the variation of pressure at the Boiler House, position B, is limited, a surplus reducing valve will be introduced at position D, which will retain the pressure there at approximately 200 lbs. per sq. in. Safety valves of the high-lift type fitted at the point of interconnection, position C, will prevent any excess pressure rise in the older system. These valves will be capable of discharging the maximum amount of steam that can pass the valve at position D.

The three water tube boilers at position B are of the latest type of unit construction, each boiler being independent and equipped with superheater, economizer, grit arrester, induced and pressure fans, mechanical grates, and the necessary apparatus for burning home-produced liquid fuels. The breeze fuel is handled by means of belt conveyors into overhead bunkers and the ashes are discharged from the ash pits by means of water sealed paddles and conveyed to an overhead hopper by belt conveyors. The normal evaporative capacity of each boiler is 30,000 lbs. per hour. The combustion chambers are large to enable home produced liquid fuel to be burned in conjunction with solid fuel, or alone without damaging the grates, and additional air can be admitted above the fire.

A boiler of this description has not the inherent reliability of the Lancashire type, being dependent upon the functioning of the ancillary plant. The auxiliaries are arranged for electric drives, and the boiler house being at some distance from the main source of electric supply, a non-condensing turbo-alternator is being installed at the boiler house to provide electric current which will be supplementary and a standby to the main supply. The exhaust from the turbine will be used to supply steam to a de-ærating plant, the switchgear being so arranged that in normal running, the load, and consequently the available exhaust steam, can be adjusted to meet the requirements of this plant.

The furnaces of these boilers are similar to those in use at the Products Works and will be described later in the Paper.

Considerable attention has been given at this Station to the desirability for supplying superheated steam to the various steam prime movers, as apart from the decrease of wear on turbine blading, there is a decided increase in efficiency by its use on all types of engines.

The initial temperature of about 300-350° C. at the boilers can be retained reasonably constant, but the temperature on long mains varies with the change of velocity of steam in the main, which is dependent on the load requirements. All modern turbines are made of materials suitable to withstand the maximum temperature, but none of the older reciprocating engines are suitable for temperatures exceeding 200° C. Therefore, where such engines are so situated that the steam supply may at times tend to exceed 200° C., means have been provided for controlling the temperature rise.

Where possible sufficient saturated steam from the 130 lbs. per sq. in. system is mixed with the superheated steam to lessen its temperature to the required point. Where such a supply is not available and the quantity of steam is not great, sufficient lagging is removed from the main to obtain the desired effect, sections of lagging being made removable for this purpose.

De-Superheaters.

Where the quantities of steam dealt with warrant the expenditure, desuperheaters are employed, the reduction in temperature being thereby employed to produce a corresponding increase in the quantity. Figure 3 shows a

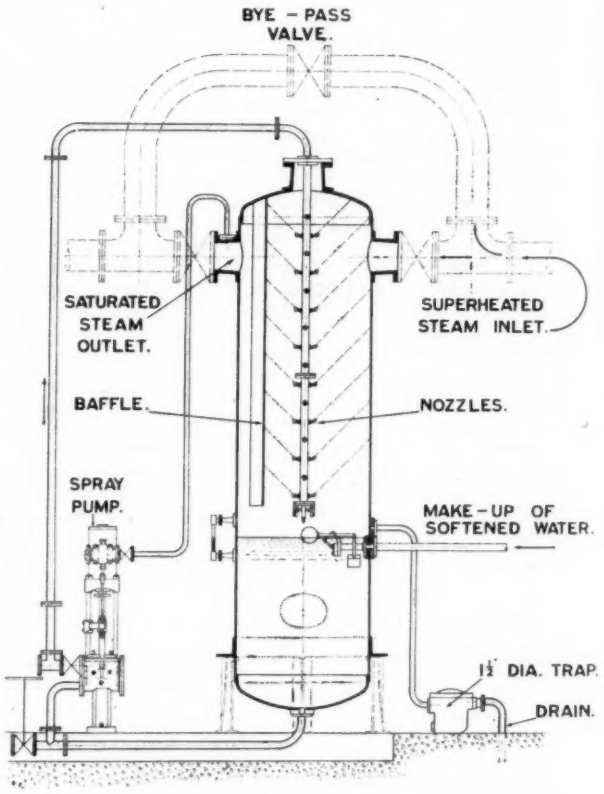

FIGURE 3.—*Diagrammatic Arrangement of De-Superheater at the Beckton Works of the Gas Light and Coke Company.*

design which has proved very successful. Steam passes through a constant spray of water. The water which does not evaporate in reducing the steam temperature to saturation point returns to the base of the vessel, and being recirculated by the pump it rapidly absorbs heat and is raised almost to boiling point. The loss of water by evaporation is made up by the admission of feed water through the automatic valve. The steam passes from the vessel saturated, and is again raised in temperature to 200° C. by mixing with superheated steam by-passed from the inlet side.

It will be noted that no thermostats are necessary, as once the by-pass is adjusted to give the correct temperature at the outlet, the same proportions pass through the vessel and the by-pass irrespective of the total quantity passing.

Electrical Plant.

Normal electrical needs are generated at E, Figure 2, the plant installed consisting of three turbo-alternators of

850, 1500, and 2000 KW. capacity. The first two, installed in 1926, generate at 440 volts and the larger machine, installed in 1928, at 6600 volts. They are interconnected by transformers, most of the transmission being carried out at the higher voltage. In addition, there are three synchronous motor generators which supply the original electric generator houses at positions F and G. These are now used as sub-stations, and the original plant is kept for emergency use. The motor generators are used in addition to correct the power factor, being arranged so that they can run with sufficient leading characteristics to enable the power factor at the station to be kept at or about ·9 lagging.

The recent coke oven extensions reduced the reserve capacity of the station to such a point that additional generating plant was necessary. In view of the dependence of the whole of this large and important works on the reliability of its electric supply, it was considered undesirable to place all the machines in one engine room as the possibility of a complete breakdown of the whole station, although remote, could not be ignored. An opportunity occurred of purchasing in excellent condition a second-hand machine of 3000 KW. capacity at 6600 volts, ample in emergency to deal with the whole load of the works. At the same time plant in an engine room H became obsolete, so the 3000 KW. machine was installed therein and now forms a complete and independent generating station.

The transmission, as mentioned before, is generally at 6600 volts. The main switchgear at this voltage is of the ironclad totally enclosed type, and the principal switchboards are provided with dual solid insulated busbars. This type of busbar is very essential with higher voltages as it allows extensions or alterations to be carried out in safety without any cessation of the supply. The switches are fitted with inverse time relays, and as alternating current, when ruptured, can set up very heavy surges of current many times greater than the rated capacity of the generating plant, the switchgear is designed to have a maximum rupturing capacity of 100,000 K.V.A.

The generators and transformers are safeguarded by the provision of Mertz-Price protective gear which comes into operation in the event of the phases becoming unbalanced through any external or internal defect.

The Generating Station is also equipped with a voltage regulator.

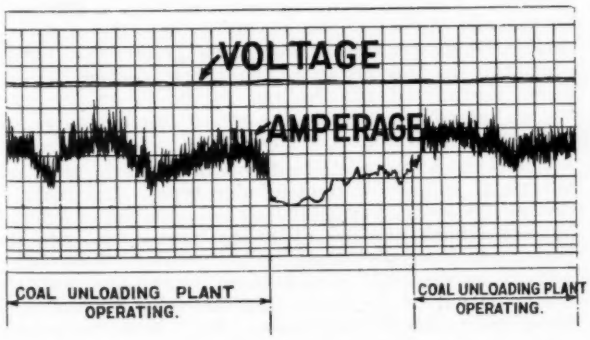

CHART 1.—*Showing the Effect of Heavy Load Variation on Voltage and Amperage at the Electric Generating Station of the Beckton Works of the Gas Light and Coke Company.*

Chart 1 shows the effect the coal unloading plant has on the output of the station. The eight cranes have a maximum capacity of 2000 tons of coal per hour and can unload two steamers simultaneously in about four hours. It will be noted that the voltage remains remarkably steady.

Table 1 gives details of a typical day's run on the Generating Station, one 2000 KW. machine being in action. The circulating and condensate pump motor is connected directly to the leads from the main alternator to ensure that there is no loss of vacuum in the event of the main circuit breakers coming into action. For this reason the output of the machine is metered as the net quantity available for works use and does not include the consumption of the auxiliaries. If allowance is made for this current the steam consumption is 16·23 lbs. per KW. hour.

TABLE I.—*Details of a Typical Day's Run on the Generating Station of the Beckton Works of the Gas Light and Coke Company.*

2000 KW. set running.
Period—6 a.m., 23rd February, 1932, to 6 a.m., 24th February, 1932.

Average pressure on 11 waste heat boilers	154·33 lbs. per sq. in.
Average temperature ,, ,, ,,	264·30° C.
Average pressure at turbine stop valve	137·24 lbs. per sq. in.
Average temperature ,, ,,	219·51° C.
Total quantity of condensate metered	488,000 lbs.
Total units metered	28,860 KW.H.
Steam consumption	16·909 lbs. per KW.H.
Maximum load	1950 KW.
Minimum load	656 KW.
Load factor	61·6 p.ct.

Steam for Power and Process Work.

The carbonizing plant of this station consisting of horizontal retort settings, and the coke ovens, does not afford much opportunity for the use of back pressure steam. The turbines of the water gas plant blowers, however, exhaust into a common main which supplies steam to a direct contact water heater at the inlet of the water softening plant. Normally the steam is completely absorbed and raises the temperature of the whole boiler feed supply for the station to 40° C. In addition, indirect heaters supplied with steam from the same source raise the temperature of the feed to the waste heat boilers of the water gas plant to 90° C., while the feed to the retort house waste heat boilers is raised to a similar degree also by indirect heaters, the necessary supply of exhaust steam being obtained from the boiler fan turbines.

An interesting development in gas boosting is now being erected in connection with the new activated carbon benzole plant. This plant at full load will throw a pressure of about 15 in. water gauge. All the coal gas streams will converge into an engine room where the gas will enter at a pressure of 1 in. water gauge the inlets of three turbo-boosters which will have a capacity of 2 million c.ft. per hour each, one machine being in reserve.

They will be fitted with a governor which will keep the inlet pressure constant. The outlet pressure will be sufficient to pass the gas through the benzole plant and reach, again at a pressure of 1 in. water gauge, the inlet of three other turbo-boosters situated in the same engine room, where it will meet the stream from the water gas plant. Each of the latter machines will have a capacity of 3 million c.ft. per hour, one machine being in reserve. These machines also governed on the inlet side will intimately mix the two gases and boost into the several station holders.

Low pressure steam at 5 lbs. per sq. in. is required for use in the benzole plant, and this is provided by the turbines driving the boosters. As the quantity of steam used in the plant will be at times less than that passing through the turbines, three of the machines will be of the pass-out type, the remainder being simple back pressure machines.

The pass-out turbines will be provided with special oil operated valves in the casings, which will automatically allow steam to leave the intermediate stages in sufficient quantity to retain the pressure constant in the low-pressure steam main, the surplus steam passing through the further stages to a condensing plant.

At the time of writing this Paper the coke oven extensions are being put into operation, but the whole equipment is not complete, so that no test figures are available. In the first half-year of 1931 78 per cent. of the steam requirements of this station were raised by waste heat.

(ii) BOW COMMON.

The Bow Common Works of the Gas Light and Coke Company were reconstructed in 1927-29. The gas-making plant now consists of one retort house containing 68 continuous vertical retorts and two carburetted water gas sets. 525 tons of coal can be carbonized daily. The daily output of gas is 11 millions of cubic feet.

Figure 4, below, gives a thermal balance of the heat in the producer fuel.

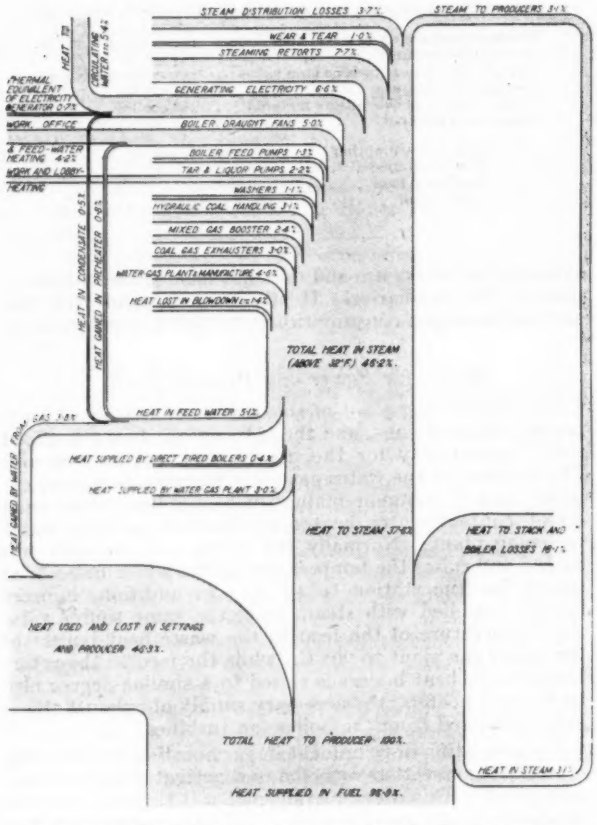
STEAM DISTRIBUTION LOSSES 3·7%
STEAM TO PRODUCERS 3·4%
WEAR & TEAR 1·0%
STEAMING RETORTS 7·7%
GENERATING ELECTRICITY 6·6%
BOILER DRAUGHT FANS 5·0%
BOILER FEED PUMPS 1·3%
TAR & LIQUOR PUMPS 2·2%
WASHERS 1·1%
HYDRAULIC COAL HANDLING 3·1%
MIXED GAS BOOSTER 2·4%
COAL GAS EXHAUSTERS 3·0%
WATER GAS PLANT & MANUFACTURE 4·6%
HEAT LOST IN BLOWDOWN 1·5%
TOTAL HEAT IN STEAM (ABOVE 32°F) 46·2%.
HEAT IN FEED WATER 5·1%
HEAT SUPPLIED BY DIRECT FIRED BOILERS 0·4%
HEAT SUPPLIED BY WATER GAS PLANT 2·0%
HEAT TO STEAM 37·6%
HEAT TO STACK AND BOILER LOSSES 19·1%
HEAT USED AND LOST IN SETTINGS AND PRODUCER 40·3%.
TOTAL HEAT TO PRODUCER 100%.
HEAT IN STEAM 31·
HEAT SUPPLIED IN FUEL 96·9%.

FIGURE 4.—*Heat Balance Diagram for the Bow Common Works of the Gas Light and Coke Company.*

Table II., below, summarizes the items of the power plant.

TABLE II.—*Summary of the Power Plant at the Bow Common Works of the Gas Light and Coke Company.*

Steam Raising Plant—

3 retort-house waste heat boilers.
2 water gas waste heat boilers.
4 8 ft. by 30 ft. Lancashire boilers.

Steam Engines—

3	reciprocating	jet condensing	driving	exhausters
2	,,	tandem compound M.C.	,,	,,
2	,,	vertical compound S.C.	,,	300 KW. alternators
1	,,	vertical non-condensing	,,	gas boosters
1	,,	high speed vertical non-condensing	,,	w.g. blower fan
3	,,	vertical non-condensing	,,	washers
2	,,	twin non-condensing	,,	hydraulic engines
6	direct-acting		,,	feed pumps
25	,,		,,	miscellaneous pumps

Electric Motors—

7	totalling	73½ H.P.	carbonizing plant
1	,,	12 ,,	coal unloading
4	,,	134 ,,	coal handling
7	,,	44 ,,	coke and breeze handling
4	,,	92½ ,,	carburetted water gas plant
3	,,	29 ,,	gas drying plant
2	,,	39½ ,,	water pumping
3	,,	36½ ,,	miscellaneous
Total 31		Total 461 H.P.	

The water gas plant, not being provided with generator boilers, is not entirely self-supporting in regard to its steam requirements.

The amount of steam shown as produced by the direct fired boilers is nominal as they are mainly on banked fires.

A reduction in the steam used would probably be effected by using exhaust instead of live steam for the retorts and producers, by further electrification and the provision of condensing plant to deal with the steam from the engines exhausting to atmosphere; but any economies in steam consumption so made would not be reflected in financial savings as only 1000 tons of fine breeze are used per annum in the direct fired boilers, and this quantity could not be materially reduced as it is required mainly for banked fires.

It may be suggested that a saving in retort house fuel might be effected if a complete system of regeneration was applied to the producers, but this would involve increased capital and maintenance charges and add complications to a simple and highly efficient plant.

Two waste heat boilers are normally in action, and three direct fired boilers are kept on banked fires. At times there is a surplus of steam from the waste heat boilers, and to avoid blowing off at the safety valves, the practice is to slow down the fans. The chimney dampers are always kept open so that the draught on the settings is not affected thereby.

Apart from priming of these boilers and a consequent loss of superheat, no trouble whatever has been experienced with the plant.

Excluding capital charges, the average cost of steam is 5·8d. per ton and the cost of electricity ·25d. per B.O.T. unit.

The consumption of steam by the electric generating plant on full load is 24 lbs. per KW. gross output, the average consumption is 35 lbs. per KW. gross, and 40 lbs. per KW. net after allowing for the current consumption of the auxiliary plant.

(iii) BRENTFORD.

Steam System.

The Brentford Works of the Gas Light and Coke Company is in a process of extension which has involved almost complete reconstruction. Owing to the peculiar restrictions of the site between the river and the High Street, the plant will be extremely compact.

One of the two retort houses, each of which will contain 48 intermittent chamber ovens, together with most of the ancillary plant is in operation, while the fully automatic water gas plant will be completed this year. The works when finished will have a daily output of 15 million cubic feet of gas per day.

Four waste heat boilers, two in each retort house, and two waste heat boilers in the water gas plant will eventually be interconnected with three water tube boilers, all working at a pressure of 160 lbs. per sq. in.

A steam accumulator of a total capacity of 12,000 lbs. of steam levels out any difference between the supply and demand. A steam accumulator necessitates a difference in pressure between the incoming and the outgoing steam, the greater this difference, the greater the storage capacity. In this instance, the range is from the full boiler pressure of 160 lbs. per sq. in. to 100 lbs. per sq. in., at which pressure the steam prime movers are designed to operate.

The retort house waste heat boilers are of the standard horizontal cylindrical multitubular type. The turbines driving the induced draught fans are arranged to exhaust against a back pressure of 20 lbs. per sq. in. into the mains which supply steam to the ovens. Two superheaters are provided to each boiler, one to deal with the whole output of the boiler and the other to deal with the exhaust from the fan turbine. Each boiler has a rated capacity of 5000 lbs. of steam per hour.

The water tube boilers are of the unit type, each being provided with its own induced and blast fans, economizer, superheater, grit arrester, chimney, and driving gear to the mechanical grate, and having a capacity of 12,500 lbs. per hour.

The furnaces for burning coke breeze are similar to those at the Tar and Ammonia Works, which are described later in the Paper.

One of the boilers is fitted with steam driven fans for emergency use; the fans on the other two, together with the grates, are motor driven.

Fuel is fed into the overhead bunkers in the boiler house direct from the screening plant by means of belt conveyors. The ashes are removed to an overhead hopper by means of tip wagons and a skip hoist.

In direct communication with and adjacent to the boiler house is a pump room containing the boiler feed,

tar and liquor pumps, together with the controlling mechanism of the steam accumulator.

The waste heat boilers in the water gas plant will be of the normal upright inclined type.

The generators will be provided with mechanical grates and annular boilers; the blast fan turbines will be arranged to exhaust into the common condenser system, while the feed will be heated by exhaust steam from the various pumps in connection with this plant, together with that from the coal gas rotary washer engines.

The water supply for the works is drawn from the river by vertical centrifugal pumps. Part of it is used direct as circulating water for the steam condensers, the remainder being re-pumped by horizontal centrifugal pumps to overhead tanks for general works services. These pumps are all electrically driven. Warm water from the outlet of primary gas condensers is re-pumped by small steam turbine driven centrifugal pumps to the inlet of the water softener, where it is further heated to a temperature of 80° C. by direct contact with exhaust steam from the several pumps in the vicinity.

Two systems of steam mains are provided; a 6-in. connects the boilers to the inlet of the steam accumulator, and a main of 8-in. bore supplies steam to the various items of the steam using plant from the outlet of the accumulator. The former works at a pressure of 160 lbs. per sq. in., and the latter at 100 lbs. per sq. in. This difference in pressure is regulated by special oil pressure operated relay valves.

To enable the accumulator and its regulating valves to be shut down for inspection, a water pressure relay operated reducing valve is provided, coming into action in the event of the pressure in the lower pressure main dropping 3 to 4 lbs. per sq. in. The steam mains in the power house are in duplicate; each main supplies one-half of the machines or pumps therein, while the whole lay-out allows almost any portion of the steam pipes to be shut down for repairs without interrupting the manufacture of gas.

The main power house will eventually contain the following plant:—

Ground Floor.

3 Water gas turbo blowers in a sound-proof room.
2 Steam condensers.
2 Barge loading tar pumps.
Gas, steam, and water mains.

1st Floor.

6 Coal and water gas exhausters.
3 350 KW. turbo-alternators.
1 50 KW. motor-generator.
2 Variable frequency alternators.
7 Hydraulic and service pumps for the water gas plant.
Control gear for the relay reducing valve.
Main switchboard.

Electrical Plant.

The turbo-alternators are arranged with the steam condensers integral with the turbines. The machines are designed for an overload of 25 per cent. and generate three-phase alternating current at 440 volts, 50 periodicity, with a power factor of ·7. The condensate pumps are driven from the main shaft by gearing and the air pumps are of the ejector type.

The motor generator is used to supply direct current at 220 volts for the producer telpher, the overhead trolley equipment of which could not be conveniently protected so as to allow the use of alternating current at the higher voltage, and also for the variable speed grate motors of the water gas plant and certain other minor services. It is duplicated by a gas engine driven generator of similar capacity, situated on the other side of the High Street, in proximity to the waterless holder, and which is fitted with direct current motors to drive the pumps, the Company's practice being to arrange two supplies of current for this purpose, each supply being independent in every respect.

The two small motor alternators are driven by variable speed direct current motors and generate three-phase alternating current having at the maximum speed of the machine a voltage of 220 and a periodicity of 44. The current will be used to operate the special motors for driving the automatic gear of the water gas plants. These motors are designed to keep in synchronism with the alternator so that any variation in the speed of this machine is reflected in a corresponding and exactly similar degree in each water gas set.

The main switchboard is of the open type mounted on black enamelled slate. An automatic voltage regulator is fitted to the main generator panels, a very necessary adjunct where comparatively small generating sets are subjected to violent surges of current due to the starting up of relatively large motors.

The main generators are protected from internal faults by Merz-Price gear and the board is fitted with a full range of indicating and metering devices.

The coal unloading cranes, which run on a track above the main coal bunkers, were originally driven by gas engines. The capacity of these cranes was insufficient to deal with the increased tonnage of coal required by the new plant, so electric motors of greater power were substituted for the engines, and the speeds of the various operations were raised sufficiently to enable the cranes to deal with a 50 per cent. greater tonnage than hitherto.

Unfortunately, at the time this Paper was written, it had not been possible to run any tests on the partly finished plant, so that an analysis of the steam and electrical consumptions cannot be given.

Carbonizing Plant.

The chamber ovens are provided with an efficient system of recuperation and the coke is discharged at a relatively high temperature, so that the heat available from the settings for raising steam is considerably less than with continuous vertical installations. In consequence, every effort has been made to ensure the conservation of steam. Figure 5 shows that the turbo-gas boosters are the only steam driven units of which the exhaust is neither condensed nor utilized for process work nor heating purposes. These machines—part of the original plant—are intermittent in operation, and being situated on the other side of the High Street, it would be unprofitable to arrange for the disposal of the steam other than to atmosphere.

The sensible heat in the coke is dissipated by quenching with water, a loss which is unavoidable as the restrictions of the site would not allow a dry quenching steam-raising plant to be installed. Apart from this, it is doubtful if the heavy capital expenditure involved would be justified by the saving of a comparatively small quantity of fine coke breeze, more especially in view of the low handling costs for fuel and ashes, and the necessity for installing direct fired boilers for use in case of emergency.

(iv) Tar and Ammonia Works.

The Tar and Ammonia Works of the Gas Light and Coke Company is provided with a battery of eight water tube boilers, each of a rated evaporative capacity of 20,000 lbs. of steam per hour, and fitted with economizers and superheaters.

The Staff at this Works has devoted a great deal of attention to the evolution of a type of furnace which will burn coke breeze efficiently, and the experience gained there has been used in the design of furnaces for all subsequent boiler installations. The furnace patented by the Company and Messrs. Adam and Gray, who have been responsible for its success, is shown in Figure 6. Above the ignition arch, position A, is a secondary arch, position B, so arranged that a proportion of the products of combustion pass to the front end of the furnace, heat up the incoming fuel and return to the combustion chamber by the passage C between the arches. This heating of the incoming fuel ensures rapid and certain ignition and the return flue entirely eliminates the nuisance of the emission of smoke into the boiler house.

The boilers are designed for a working pressure of 300 lbs. per sq. in., but at present the pressures do not exceed 170 lbs. per sq. in.

Steam is required at a pressure of 10 lbs. per sq. in. for the manufacture of sulphate of ammonia, and is reduced to this pressure by means of two 900 KW. back pressure turbo-generators which supply sufficient direct current at

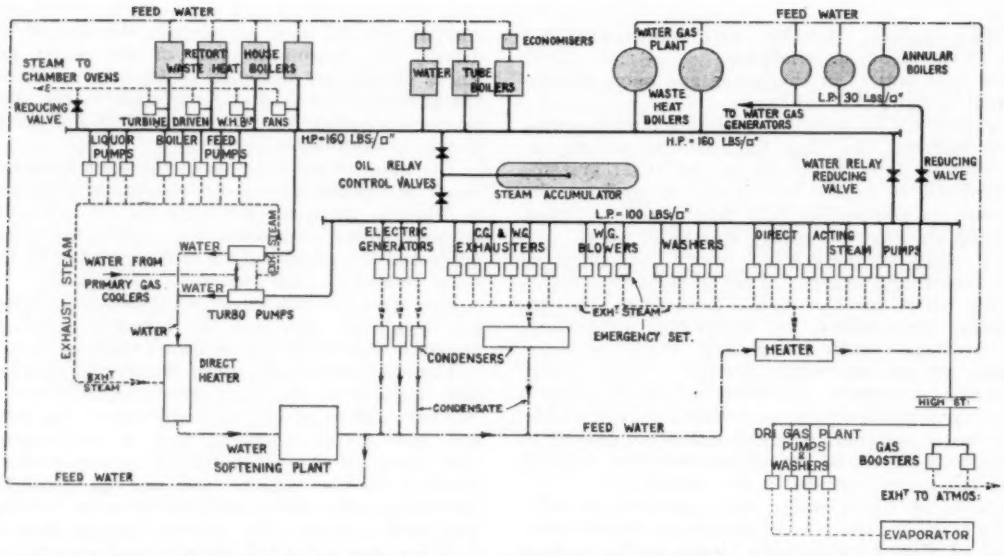

FIGURE 5.—*Diagram of Steam Exhaust and Feed Systems at the Brentford Works of the Gas Light and Coke Company.*

220 volts to meet the entire electrical requirements of the Works.

The installation is highly efficient, and excluding capital charges, steam is produced at a cost of 1s. 9d. per ton and electricity at 0·25d. per KW.-H.

CONCLUSIONS.

In conclusion the methods at present adopted to increase economy in the generation and use of power are summarized as follows:

(*a*) The use of waste heat and low grade fuel for the raising of steam.
(*b*) The combined use of power and process work by the use of back pressure or pass out turbines.
(*c*) The adoption of the most efficient form of prime movers where the direct use of steam is essential.
(*d*) The extended use of electrical transmission.

In addition, the relative economies of waste heat boilers and regenerators, or a combination of the two systems has received attention, but the subject is too wide to be treated in detail in this paper.

That it is worthy of consideration may be shown by the results now being obtained with the coke oven installation at Beckton. These ovens are fitted with reversing air and waste gas regenerators which are so efficient that the waste gases leave the outlet of the regenerators at a temperature of about 250 C., which is approximately the same temperature at which the waste gases are discharged to the chimneys from the horizontal retort settings after passing through a simple recuperator and waste heat boiler.

Apart from such considerations as capital costs, labour, &c., the financial saving in fuel only required for use in the producers and for steam raising may be expressed as follows:

	Pence.	Per Ton of Coal Carbonized. Pence.
HORIZONTAL RETORT SETTINGS.		
Producer fuel—		
Coke, 321 lbs. at 24s. per ton	41·2	
Breeze, say, 15 lbs. at 6s. per ton	0·5	
		41·7
In addition, 1000 lbs. of steam are raised by the waste heat, 120 lbs. of which is used to drive the fans, leaving 880 lbs. available for use.		
COKE OVENS.		
Producer fuel—		
Coke, 177 lbs. at 24s. per ton	22·7	
Breeze, 69 lbs.	..	
To raise 880 lbs. of steam in direct fired boilers, 176 lbs. of breeze will be required.		
Total breeze, 245 lbs. at 6s. per ton	7·9	
		30·6
Difference		11·1

Comprehensive records are kept of the production and use of power from which monthly statements of costs are compiled, while investigations of new methods which may lead to greater efficiency are being undertaken continually.

I wish to express my indebtedness to the Directors of the Gas Light and Coke Company and to the Chief Engineer, Mr. Thomas Hardie, for their permission to publish the information contained in this paper and my thanks to various members of the staff for their valuable assistance.

DISCUSSION.

The PRESIDENT: I should like on your behalf to express our very great indebtedness and our very sincere and hearty thanks to Mr. Birks for the splendid paper which he has produced on the co-ordination of power in relation to gas-works. It certainly is a paper which will be of outstanding value to every member of the Institution; and I do not think you can show your gratitude to Mr. Birks in a

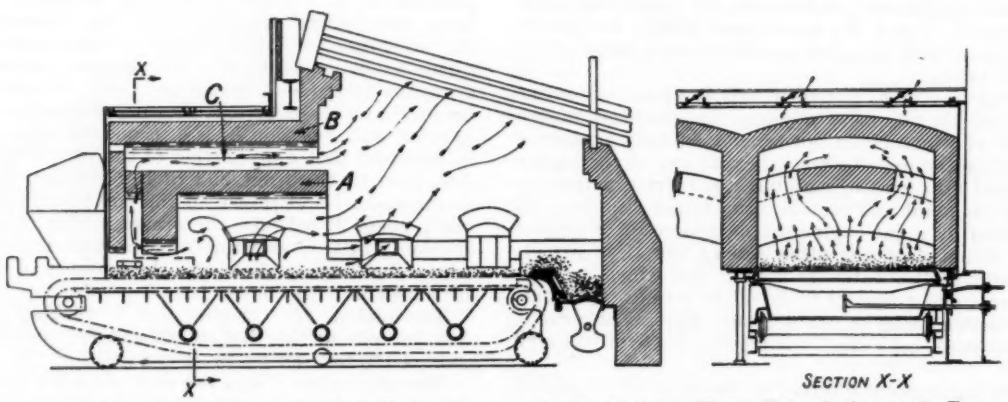

FIGURE 6.—*Special Breeze Burning Boiler Furnace for Chain Grate Water Tube Boilers at the Tar and Ammonia Works of the Gas Light and Coke Company.*

more practical manner than by giving this paper the fullest discussion possible. I should like also, on behalf of the Institution, to express our thanks to the Directors of the Gas Light and Coke Company and to Mr. Hardie, their Chief Engineer, for the generous manner—as is their invariable custom with regard to matters of this kind—in which they have permitted Mr. Birks to publish this invaluable information for the benefit of the Institution and of the Gas Industry as a whole. I will now call on Alderman F. J. West to open the discussion on the paper.

Alderman F. J. West: I think you will agree with me that Mr. Birks has earned our thanks and is to be congratulated on the very lucid exposition he has given in his paper of the complicated problems relating to the production of power and fuel utilization which confront the engineer in a modern gas-works to-day. His paper illustrates the extraordinary range of engineering technique involved in the production of town gas, and Mr. Birks has emphasized in his paper the fact—perhaps unconsciously, and a fact not appreciated by those outside our Industry—that the gas engineer, for the successful solution of his many problems, requires as wide a range—indeed, I think I may say a wider range—of technical and practical knowledge than is required in any other branch of engineering. To take the case presented by Mr. Birks, not only is the engineer called upon to generate power and to supply it for the multiplicity of uses either direct in the form of steam or indirect through the media of hydraulic power, electricity or compressed air, but he has to apply it to a great variety of uses; and in the production of that power he is called upon to use waste fuels and waste heat of varied descriptions.

Electricity Generated from Waste Heat.

There are two outstanding features in the paper referred to in the summary. The first is the extraordinary extent to which waste heat is used in gas-works to-day for the production of cheap power. Mr. Birks tells us that there are 107 waste-heat boilers in use to-day in the works of the Gas Light and Coke Company, and there is also a reference in the paper to the extended use of electrical transmission. Although engineers in some works are diffident to introduce electricity for reasons which we appreciate, it is clear that this prejudice is disappearing. I think we may say that not only is electricity firmly installed as the most widely adopted method of power transmission in the modern gas-works, but the gas-works is becoming almost entirely self-supporting in the generation of its own current. Many engineers to-day, particularly those in towns where the gas and electricity undertakings are controlled by the municipalities, are confronted with the problem of deciding whether to generate their own electricity or to take it from the local electricity undertaking. Where electricity is generated on a gas-works by steam produced in waste-heat boilers, I think ½d. per unit is an accepted figure; but ignoring the question of waste heat recovered, in cases where it is not available or is not suitable for the locality in which it is situated, the question as to whether the engineer can produce electricity on the gas-works as cheaply as he can obtain it from the electricity undertaking is a problem which many have to decide. I should like to ask Mr. Birks whether from his experience he can tell us what the cost of electricity per unit is likely to be where waste heat is not available, using sets of, say, from 100 to 250 kw. The figure he gives of ¼d. per unit is, of course, for a very large installation and one of a size with which not many of us have had experience.

Another point that is interesting to me is that Mr. Birks has rightly emphasized that an electrical equipment in a gas-works must be of robust design. Many of us have had experience in this connection, and we know the difficulties of attempting to use the ordinary motor and the ordinary type of switch gear which is much too light under the difficult conditions of dust, &c., which prevail in a gas undertaking to-day. I have been deeply interested in perusing Mr. Birks' paper; he has given us a very interesting account of power production in his own case, and it is a very valuable addition to the technical records of the Institution.

Dr. E. W. Smith, C.B.E.: The Gas Light and Coke Company have again laid the whole Institution under a deep debt of gratitude for having been prepared to put before us a paper of this type, novel in its kind and useful in the detail which it gives. But I do not think Mr. Birks would be in disagreement with me if I suggest that the paper forms an introduction to a much more comprehensive handling which he is likely to be in a position to give at a later date. It is a paper which stimulates every gas engineer to look into what can be done on his works along similar lines or along lines which may be suggested by this paper, and which may not be quite similar. I think that Mr. Birks, with his knowledge and experience of diversified works, all of them fairly big, would be one of the first to say that there will be no standard method of dealing with the various sources of energy and power and fuel that are available at different works.

Dry Coke Cooling.

A very large number of the points which Mr. Birks makes should be invaluable to all gas engineers. It is interesting to realize that at a works such as Beckton, 78 p.ct. of the power required is raised from waste heat, that at Bow Common the cost of raising steam in waste-heat boilers is 5·8d. per ton, and that from breeze it is 1s. 9d. per ton. That is a very big difference. I suppose that the cost of breeze would be 6s. per ton as indicated in further tables. Although steam is of primary importance, it is to be noted that at Brentford apparently there is no justification for going in for dry coke quenching. That is a very important point to have been brought out in this paper. A good many gas engineers, and a good many contractors, have given and are giving very careful consideration to the possibilities of utilizing for steam raising the heat that is in hot coke as discharged; and for it to be indicated that, at any rate on one particular works—and it is not a general indication—dry coke quenching for steam raising is not attractive, due to the high capital cost, is of importance.

Another important thing which every gas engineer can apply is the advantage that accrues from the use of the superheated steam in transmission about the works, and the lagging of mains. Those are devices which are in use in a good many works, but which can be applied much more generally than is found. Another point is the importance of high velocities in steam mains. It would be interesting if Mr. Birks could tell us in his reply what range of velocities he has found to be of the greatest utility.

Use of Gas Engines.

We are not surprised that Mr. Birks has not given much space in his paper to the use of gas engines. His Company has very large works, and apart altogether from the convenience or lack of convenience of a gas engine a great deal depends on the price at which gas is charged to the gas engine even on one's own works, and if the view could be adopted that gas can be charged for power purposes and for other purposes where there is a constant outlet for gas on the works, at a very low cost, at a cost which is much lower than any industrial supply, I think it is justified. It is justified on similar lines to the justification that is growing among us for benzole extraction. This load is an extra load, and in any case the demand for gas is constant; whatever extra gas you make, or whatever you take out of the gas and sell, is of advantage within very broad limits, and it is justifiable to charge for gas for one's own use at one's own works at a very much lower rate than is usual on works to-day. I think if Mr. Birks can say just what he feels about this question for charging for gas for gas engine purposes, it might be very useful.

Then I should like to point out something which Mr. Birks and I have already discussed, and which he acknowledges in his paper—that in making this comparison of the relative advantages of non-recuperative carbonizing plants, *plus* waste-heat boilers, as against complete regenerative carbonizing plants and the use of breeze, he has, in the comparison he has made, assumed in his costs as an asset the coke breeze which is brought into the works, rather than being dependent on the coke breeze that is made on the plant. In other words, if the steam requirements were such on other works that he has described as to demand a greater quantity of breeze, and he brought in breeze from another works more than he made on his own works, then, because of the low cost of coke breeze, his costs will come down in a manner similar to that shown in the paper.

Mention is made in the paper of a regenerative setting in which the temperature of the waste gases is reduced to 250° C., which approximates, as he says, to the temperature of the outlet of waste-heat boilers. I would like to ask him where that temperature of 250° C. was taken. Judging by my limited experience it would seem that the temperature was taken, as usual, at the bottom of the stack; but if the temperatures were taken actually at the outlet of the generators, they would be probably from 50° to 100° higher. That is the normal experience with that type of plant, so that actually the losses from a regenerative setting are usually very much higher than the losses at the outlet of a waste-heat boiler.

My last point is that of the priming in waste-heat boilers. It would be interesting if Mr. Birks could indicate what methods he thinks might be adopted for reducing priming, and if he would indicate the main cause of priming. As regards the standardization of heating surfaces in waste-heat boilers, there is no doubt that there is a real necessity for standardizing the nomenclature, if you like, of heating surfaces, and I personally would advocate strongly that the

standardization should be on the heating surface on the fire side of the tubes.

Again, I wish to thank Mr. Birks for his most valuable paper, which I shall refer to personally on many occasions in connection with my own work.

Mr. H. D. MADDEN (Cardiff): This is a subject which I have been particularly interested in. I quite agree with the previous speaker that Mr. Birks' paper is what we might call the initial paper and that we might expect to see more written on this important subject in the future. We as an industry have for many years suffered from the fact that we have had a too abundant supply of cheap fuel on the works and it is all to the good that the utilization of waste heat and breeze for the production of steam should receive specialized attention. You may be interested to hear that for some years past in the Diploma Examinations of the Institution, special stress has been laid upon this important subject of the utilization of waste heat for the purpose of power production. In our own Company also we have given it special attention and are at the present time harnessing what we think is the last amount of waste heat that we have to spare, by means of a waste-heat boiler.

QUESTION OF WATER SUPPLY.

There is one important factor not touched upon by Mr. Birks, and that is the feed water supply to the whole of the works, or rather the water supply. Therefore, I would like to draw attention to the conservation of water for steam raising purposes. In our own case we have isolated every boiler house and had a meter put on in each case so that the water used daily can be compared with the works meter. This gave us a tremendous control, and after the first year we found there was a saving of over £800 a year in the water bill. Sir Charles Bird, the Chairman of the Cardiff Water Works, is present, and he will, I think, agree with these figures. Again, there is the exhaust heat to which Mr. Birks has drawn attention, and the whole of our feed water in Cardiff is raised to 190° Fahr. before it enters the boiler.

There are just two points I should like to ask Mr. Birks to make clear. I used to know Beckton very well, but I was not very clear from the drawing in the paper as to whether they have one circular steam main in which the whole of the steam for the whole of the works, with the exception of the tar works, is put. Then I should like to ask him with regard to the fans. Mr. Birks' comments on this matter concur with my own experience—namely, that the draught fans on the waste-heat boilers should be steam driven rather than electrically driven, provided you reclaim the heat of the exhaust steam in the feed water. Then there is another matter with regard to waste-heat boilers upon which I do not know whether Mr. Birks has had any experience. We have found, although only in the case of one boiler, that there is the formation of an acid moisture when the boiler is shut down, and we have had the burning of the clothes of the men who have been sent in to clean the boiler. We have tried many ways of dealing with it. I know it is a question of temperature of the outlet gases, and we have increased this materially. The difficulty, however, only occurs in one boiler, as I have said, and I should like Mr. Birks to deal with that if he will. In conclusion, I should like again to express my appreciation of this most valuable paper, which is one that we can start off with but not finish with.

Major W. GREGSON (Spencer-Bonecourt, Ltd., and Babcock & Wilcox, Ltd.): I would like to refer briefly to four points arising out of the paper. Firstly, Mr. Birks states that direct-fired boilers are necessary even when the whole or the greater part of the steam requirements is raised by waste heat. My experience shows that about 800 to 1200 lbs. of steam is required per ton of coal carbonized. The lower figure refers to moderate to large works carbonizing on horizontals, and the higher figure to smaller works carbonizing on verticals. They represent outside limits in each case. Furthermore, these figures do not take into account water gas plants, as the latter can always be rendered self-contained by their own waste heat boiler equipment. It is now accepted that the figures mentioned above can readily be obtained from waste heat alone. I suggest that Mr. Birks' statement can hardly be looked upon as a general one—*i.e.*, applying to all gas-works—but as referring specially to the large group of works with which he is really dealing in his paper, and where the geographical situation of the works themselves—more particularly in connection with coal and coke handling plant and the operation thereof—is such as hardly to make the works typical of what occurs in the case of more conveniently situated sites. One has to realize that a gas works operating in the heart of London and reconstructed and modernized stage by stage affords engineering problems far more difficult of solution than those appertaining to the average provincial town, and there is consequential difficulty in getting the most economical combination of mechanical plant. No doubt some of the Gas Engineers present will substantiate the suggested modification to Mr. Birks' statement.

The second point deals with the question of induced draft fan drive. I agree with Mr. Birks up to a point—*i.e.*, that if there is any likelihood of interruption of electric supply, then the steam-driven fan offers greater advantage. On the other hand, the application of electricity to gas works practice has now reached such a stage of reliability that provided reasonable continuity of supply at the Power Station is assured, then the risk of shut-down by electrical failure is extremely remote. In other words, where the Works Power Station consists of more than one unit in operation at a time, and the transmission lines and switchgear are all laid out to meet real gas works conditions, electrical drive has much to commend it, firstly on the score of simplicity and secondly since it avoids a multiplicity of small heaters for re-absorption of the exhaust steam for obtaining economy.

THE SEARCH FOR A FORMULA.

Next, Mr. Birks refers at some length to the question of priming on waste heat boilers. This is a matter which has exercised mine and my colleagues' minds for a very long time, as so little condense return is available in the average gas-works—*i.e.*, one has to depend very largely on raw make-up—the latter in most cases requiring treatment. The most prolific source of water being carried over is over-concentration in the boiler, and this is a point which requires very careful regulation by the plant engineers. I very much admire Mr. Birks' effort to search for a formula correlating heating surface per foot length of boiler and diameter of boiler; but speaking for myself, in seeking after the same sort of solution I have come to the conclusion that there are so many variable factors that it is impossible to generalize on a formula, and each job has to be considered on its own merits. As Mr. Birks has pointed out, on the fire-tube waste heat boiler, the bulk of the evaporation takes place at the front ends of the tubes, and experiments carried out some time ago by me show that 69 p.ct. of the evaporation occurs in the first third of the boiler length; and designs for which I am responsible always allow for this factor.

After due consideration, it really looks as if a formula could be made involving as factors temperature drop and heat transfer applied to the cross-sectional tube area, and the total heating surface involved in this section of the boiler, but the factor of the water itself brings in such additional complications that consideration case by case appears to be the only safe and real way of handling the problem. As Mr. Birks pointed out, in a boiler which is running at a rating considerably in excess of what is considered good practice for the particular feed water involved, the provision of an auxiliary drum with separating device is a definite and positive remedy in providing dry steam for the superheater inlet and so avoiding the latter having to act as a re-evaporator, with consequential deposition in the superheater element tubes. On the other hand, in cases where steady water conditions without either priming or frothing can be obtained by carefully watching the feed water, then the provision of this extra apparatus is redundant. Cases have arisen in my own practice where boilers are now operating at duties considerably in excess of those for which they were originally designed, and the specific remedy in these cases is covered by Mr. Birks' suggestion.

My fourth point occurs in connection with the paragraph wherein Mr. Birks refers to the relative economies of waste heat boilers and regenerators, or a combination of the two systems, and where he quotes the high regenerative efficiency of the Beckton coke oven installation. I hope Mr. Birks will correct me if I am wrong, but I believe that the coke ovens at Beckton are fired by clean, cold producer gas; in other words, regeneration is possible not only on the air, but also on the gas which, of course, makes all the difference compared with retort practice where normally producer gas is delivered hot to the combustion chambers—*i.e.*, with the sensible heat *ex* producers still extant. The limits of regeneration are mathematically determined by the proportioning of the ingoing constituents and their relative temperatures to the out-going products and the temperature thereof, which explains why every hot producer gas fired type of setting affords a case for waste heat recovery, and every coke oven plant fired by coke oven gas, or again by clean cold producer gas on the lines of Beckton, allows for full recuperation by regenerators alone.

In this connection, a further point to be remembered is that there are other sources of heat loss on a carbonizing plant over and beyond the sensible heat in the waste gases, and it is possible to regenerate the incoming air of combustion by taking up a good deal of this heat which would otherwise be wasted, for instance by cooling the coke at the bottom of the retorts, or again by passing the air down the walls of the settings and so taking up heat otherwise lost by radiation—both systems being adopted on verticals.

This frees the purely sensible heat loss from the waste gases for steam raising solely, and the net result of the aggregate recovery is to give extremely enhanced over-all efficiency when studied in the heat balance sheet.

Ideal Heat Recovery.

Mr. L. H. Sensicle: I have read with great interest the splendid résumé which Mr. Birks has given of the power plant of a gas undertaking with numerous works. Mr. Birks has dealt with practically all the particular aspects of the subject, but there is one which he has dismissed rather summarily and that is a point upon which I should like to speak for a moment or two, if I may, more particularly as his remarks have been underlined by a previous speaker. I refer to the reference to the question of recovering sensible heat from the coke discharged from intermittent carbonizing plant. I do not think Mr. Birks has been quite fair in dismissing this matter in such a short manner. I think there is far more to be said for the dry cooling of coke than he has stated here. More particularly I should like to say a word or two because I have had some experience of the dry cooling of coke from intermittent plants, and I know from actual works practice that the amount of heat recoverable from such systems is a very important factor in determining the economy of operation of a carbonizing plant. If one considers that the heat discharged in the red hot coke amounts to at least half the amount of heat consumed in carbonizing the coal, one can see that the matter is of some importance, to say the least. It seems to me to be rather futile to concentrate on improvements in plant design, improvements in regenerative efficiency, &c., if we are going to allow all this heat to go to waste when one discharges the coke, by using what might be termed fire-brigade methods to get rid of this heat that has been put in with great care. The amount of heat which can be recovered is about 900 lbs. of steam per ton of coke cooled, and it can easily be calculated that, to take, for example, a coke oven plant carbonizing 1000 tons of coal per day, the amount of power which can be generated from that steam would generate 1000 kw., which is sufficient to supply the whole coke oven plant with power. To my mind the ideal system of carbonizing plant comprises reversible regeneration and the raising of waste-heat steam not from hot gases from the combustion flues but from the heat of the coke. If you are going to generate steam from hot gases from your settings, you are really getting that steam by using more fuel to heat your carbonizing plant; that is what it really comes down to. Therefore, I say there is much more to be said for this question of dry cooling of coke than has been indicated in the paper. The President has indicated that time is short, and therefore I will not take up your time any further in discussing the paper.

Mr. E. B. Tomlinson (Birmingham): I should like to add my meed of praise of the admirable paper. It is a most valuable contribution to the information available on this subject to the ordinary Gas Engineer, and will be much used for reference. The various pros and cons and types of power to be used for various purposes are clearly set out. There are a few questions I should like to ask. First, can the author give the meeting the approximate difference in cost of unloading rail-borne and water-borne coal? Relating to fuel fired boilers, I should be glad if Mr. Birks would tell us the type of plant used for grit and dust arresting from the waste gases to the chimney, with its approximate efficiency. This is a most difficult proposition, especially if coke dust is used containing a high proportion of fine powder. I am pleased Mr. Birks has made a point of using steam driven fans for the waste heat boilers. In the event of the failure of an electrically driven boiler fan, considerable trouble is caused both in the retort house and on the works generally. Chimney dampers have to be hurriedly raised and additional steam raising plant must be quickly brought into action. This means keeping boilers under slow fire for such an emergency. The diagram of the services to waste heat boilers is very interesting. Has it been found necessary to use a de-aerator for the feed water to avoid oxygen corrosion?

I am entirely in agreement that there should be some standard method of rating waste heat boilers; but even so, due consideration must be given to the rate of flow of gases through the tubes. Under the heading of compressed air, Mr. Birks says this medium was selected as being free from the possibility of freezing. I have known of compressed air distribution systems which have caused a great deal of trouble from freezing owing to condensation of moisture. Has it been found advisable to use any special type of drier? Mr. Birks mentions de-tarring by minute currents at 50,000 volts. I should be glad to know if he finds any difficulty arising by accumulation of tar on the electrodes. It is interesting to note that the cost of steam is 5·8d. per ton at Bow Common and the cost of electricity ¼d. per unit, whereas at the Tar and Ammonia Works the cost of steam is 1s. 9d. per ton, and the cost of electricity is also ¼d. per unit. May I take it that a considerable credit is given to the steam used for generating the current at the latter works, because of its subsequent use at 10 lbs. pressure for process work?

"The Degree of Dependability."

I am glad that the Author points out that however excellent electricity is as a prime mover, it has not yet attained that degree of dependability so necessary for continuous work for long periods on vital plant.

Dr. G. W. Anderson: May I offer my ardent tribute to Mr Birks on his outstanding paper, which is full of interesting details, and provides excellent evidence of the potentialities of power production in gas works? I do not propose to deal with the non-contentious facts contained in the paper, but rather with the conclusions that one can draw from the statements presented.

It was not until the post-war reconstruction period that the importance of power production and planning was realized by gas undertakings. To-day the Gas Light and Coke Company has a model system of steam and power generation, closely interlinked with the gas producing plant. The steam and power plant has assumed gigantic dimensions, annually evaporating 2 million tons of water and generating 14¾ million units of electricity. That is about 0·72 tons of steam and over 5 units of electricity per ton of coal carbonized. (The total tonnage of coal consumed by the Company is 2·78 million tons per annum.) The question which in my opinion arises out of the data given in the paper concerns the potentialities of steam and power generation in conjunction with gas-works plants, which are the more interesting in view of the low price at which different forms of energy can be produced. The cost of steam has been given at 5·8d. per ton and that of electricity at ¼d. per unit. Both exclude capital cost, but even if overhead and capital charges were added, the total cost would not be more than twice the figures stated. Some years ago, when I was in consulting practice, I investigated the steam production and consumption of gas undertakings and arrived at a potential surplus of steam, which could be made available after satisfying the requirements of the works themselves. It will not be necessary to weary you with details which were published at the time in a leading Technical Journal, but perhaps I may be permitted to quote the final figures in order to illustrate the point which I endeavour to make.

It was necessary to distinguish between two sets of conditions:

(*a*) Producer gas supplied to the carbonizing plant obtained from inside producers.

(*b*) Gas supplied from modern mechanical producers, fitted with jackets for high pressure steam generation.

In both cases the water gas production in separate plant was taken as 4000 c.ft. on the basis of one ton of coal carbonized. It was found that steam could be obtained as what Mr. Birks calls "bye-product steam" from waste heat boilers, gas producers, water gas generators, and coke cooling. The latter is not a paying proposition on gas-works, when other methods of steam generation are available; but the picture assumes a different aspect when there is a profitable outlet for the steam either for power production or for process work. The total quantity of steam available from these sources was found to be of the order of 1600 lbs. of steam per ton of coal carbonized, when inside producers were used, and 925 lbs. in the case of outside producers. From this quantity the steam requirements of the works, calculated at 700 lbs. per ton of coal carbonized, had to be deducted—a figure which is incidentally confirmed by Mr. Birks for the works of the Gas Light and Coke Company. The available surplus steam then became 900 and 225 lbs. respectively for the two cases. In addition to this quantity, steam can be generated cheaply from coke breeze. Since the average breeze yield can be taken as 145 lbs. per ton of coal carbonized, about 1000 lbs. of steam could be derived from this source, at an evaporating efficiency of 70 p.ct. The total steam available is, therefore, 1910 and 1240 lbs. respectively, the average being 1570 lbs. per ton of coal. If the steam consumption per KW.-hour is taken at 15 lbs., 100 KW.-hours can be produced per ton of coal carbonized by gas undertakings in Great Britain. Their consumption of coal amounts to 17,000,000 tons per annum, so that about 1700 million KW.-hours could be produced annually by the Gas Industry in this country, representing about 13 p.ct. of the total amount of electricity generated.

The outlet which existed for this energy is now closed, but another field is available, which should be exploited—namely, chemical processes, in which power and steam often play an important part. Mr. Birks has shown how low-pressure process steam can be obtained at low cost from power plant by employing back pressure or pass-out tur-

bines. He thus, incidentally, points the way to reducing the steam cost in the manufacture of sulphate of ammonia, which is usually assessed at £1 per ton of sulphate. The signs of the times point to the possibilities of a greater development of chemical activities on the part of the Gas Industry, which has a singular opportunity of utilizing its resources in this direction. As power is an item of inestimable value among these, it is hoped that the potentialities will not be ignored.

The Gas Industry is now at the parting of the ways and must decide whether to confine itself to the distribution of heat, power, and light, or to continue its great tradition and develop in the direction indicated by scientific discoveries and economic considerations.

Steam Generation and Requirements of Gas-Works Plant.

[Lbs. of steam per ton of coal carbonized.]

—	Inside Producers.	Outside Producers.
Waste heat boilers	1075	..
Producers	..	294
Water gas generators	160	160
Coke cooling	363	470
	1598	924
Steam required by works	700	700
Surplus steam	898	224
Steam generated from breeze	1015	1015
Total steam available	1913	1239

The PRESIDENT: I am afraid that there is no time for any further discussion of the paper this morning, but I hope that any of you who have comments to make will be good enough to send them in for inclusion in the Proceedings. I will now call upon Mr. Birks to reply to the discussion.

THE AUTHOR'S REPLY.

Mr. BIRKS: In the first place, I would like to thank very much all those who have taken part in the discussion, although I am afraid I shall not have sufficient time to answer some of the questions that have been put, because to do so it would be necessary to refer to data which I have not here.

With regard to Alderman West's query, we have no example of small generating sets of about 250 KW. which entirely derive their steam supply from fuel-fired boilers. In every case the steam is taken from waste heat or partly waste in fuel fired boilers, but apart from the question of the cost of the steam and the cost of the fuel, these small stations depend entirely on whether the labour can be subdivided—say, the exhaust house—or reduced to a comparatively reasonable quantity, and also whether the existing steam supplies enable the plant to be extended at a very slight capital cost and also enable the total generating costs to be comparatively low. In most cases of the generation of electricity from waste heat I do not think it is at all advisable to generalize. It is always very much better to take each individual case separately and go into it carefully.

As to Dr. Smith's query concerning Brentford, no space was available at Brentford for dry quenching, but I am sorry I gave the impression that we did not consider dry quenching suitable. That is not so; it has been very carefully analyzed, and one must remember that a dry quenching boiler does not eliminate other boilers. One must have either the dry quenching boiler or duplicate your fuel fired boilers to take their place in the event of their being shut down for maintenance or due to breakdowns. The velocity in the steam mains varies with the diameter and size of the main, of course, and the velocities were mainly calculated from the very excellent paper read by Newton Booth two or three years ago. With regard to temperatures at the outlet of the coke oven regenerators, I am sorry I am not quite certain whether these were taken at the base of the stack or the outlet of the regenerator. I mentioned the coke oven producers to show the possibility of efficient regeneration. The breeze required over and above that made on the plant came from other sources such as the horizontal retort house, and I only wished to stress that the boiler fuel and producer fuel are very much linked up together. As one or two speakers have said, this paper is really only an introduction and I hope somebody else will read a paper on the question of linking the two fuels together, considering the power production on a gas-works together with that of the producer fuel. I also wished to draw attention to the fact that it is undoubtedly very much more economical to conserve coke at the expense of breeze wherever possible, and use breeze made on the works. With regard to priming, in the case of the water used on the boilers of the Gas Light and Coke Company, we have found that 15 ft. per minute maximum steam release from the surface of the water more or less constitutes a point above which the boilers prime. That means that the temperature at the outlet of the boiler is an important function. As the temperature rises, so the heating surface per foot run of boiler should be reduced for any given diameter of boiler, or, putting it in another way, if the heating surface per foot run of boiler is a constant, then as the temperature at the inlet goes up, the boiler should be increased in diameter. That increases the water space available and so lowers the velocity with which the steam comes from the surface of the water.

As to Mr. Madden's remarks, we make every effort, of course, to utilize condensed steam, and that is returned into the feed systems wherever possible. Every boiler house is fitted with meters both for the feed and, wherever possible, for the fuel also. The mains at Beckton have been built up by what might be described as a series of rings. The last extension is not a ring; it is a single leg joined up to a ring, but it is in effect a ring because it is connected with the exhaust boiler house from the other end, which it is hoped will be eventually shut down and the ring then completed back to the main ring of the plant. As to the trouble Mr. Madden has had with corrosion and the burning of the clothes of the men who are working in the flues, dust of course comes down, after the boiler is shut down, in a dry powdery form, and if it is swept out directly the boiler is let down, it has no time to pick up moisture and turn into what is practically very strong sulphuric acid. We had the same trouble, but now we invariably sweep out the flues before the dust has had time to pick up moisture.

With regard to Major Gregson's query, fuel fired boilers are naturally recommended entirely on the score of reliability. The electrically driven fans apparently are rather cheap, but if you take into consideration the capital cost involved in the cables and also in the share of the standby machinery of the generating plant as well as the generating plant itself, the total cost is probably, if anything, higher with electrical transmission than it is with steam. As to Major Gregson's point concerning regeneration *versus* waste heat boiler, the coke ovens, of course, do definitely show that the regeneration is of a very high order and that the fuel is actually saved; it is not just saved on paper—it is actually saved, which is rather a different thing.

The subject of dry quenching was gone into by Mr. Sensicle but I think I have more or less answered that in replying to previous speakers.

With regard to Mr. Tomlinson's question I could not at the moment go into the cost of unloading rail borne and water borne coal, but will do so in my written reply. As for the type of grit and dust arresting apparatus, we have two or three in use, and they are all more or less efficient. All the makers claim something like 97 p.ct. efficiency for these dust arresters, but there is no method of testing the efficiency, except that one finds, after they are installed, that any nuisances which existed before have to all intents and purposes ceased. I am glad Mr. Tomlinson agreed with me about steam driven fans. It is a particular point on all large works where the boilers are scattered about, because in the event of a total shut-down of the electrical plant, very considerable inconvenience can be caused by having to run long distances and shut dampers and generally causing inconvenience to the gas operating department. With regard to the de-aerator for the feed water, at Beckton the temperature of the water entering the softener is raised to about 40° C., but previous to that being done, a certain amount of corrosion was experienced in certain of the boilers, but this has been reduced practically to nothing since the temperature of the inlet water to the softener has been raised. In the new water-tube boiler house which we are starting up, we have adopted the Weir type of de-aerator, but it has not been running any time, and therefore it is quite impossible for me to give any details of its operation. With regard to rating of the waste-heat boilers, that was not really suggested in the paper. It was merely suggested that there should be a standard method of getting at the heating surface, and that either the inside or the outside of the tubes should be accepted as constituting the basis of the calculation with regard to the number of square feet available. With regard to compressed air freezing, that is mainly a question of proper drainage of the pipe system. No special arrangements are made to dry the air before it enters the mains. As to de-tarring by means of 50,000 volt current of small capacity, I have not heard of any difficulties, but that also I will deal with in my written reply. The reason why the cost of electricity is the same at Bow Common as at the Tar Works, although the steam supply is more costly at the latter works, is that steam is credited with the work it does as a process steam.

I am afraid I cannot answer any of Dr. Anderson's questions without thinking over them considerably.

The PRESIDENT: I should like once more to thank Mr. Birks for the very valuable contribution he has made to our Transactions, and at the same time to thank all those who have joined in the discussion.

The Use of Gas as a Fuel in Industry,

With Special Reference to Future Applications

By Dr. C. M. WALTER

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INTRODUCTION.

In presenting this Paper to members of the Institution of Gas Engineers, the Author would like, in the first place, to refer to an earlier contribution which he had the pleasure of presenting conjointly with Dr. E. W. Smith, in June, 1913, on "Gaseous Heating."[1] In this some of the earlier work carried out in Birmingham on the development of Town's gas for Industrial Heating purposes was referred to in detail, and at the same time reference was made to the question of compressing Town's gas to pressures approximating one atmosphere.

It is a coincidence that the Author, in the first Section of this Paper, proposes to deal with the more recent developments in the use of Town's gas for Industrial Heating, with particular reference to technical considerations, and in the Second Section to refer to some recent experiments which have been carried out in connection with the use of Gas compressed to approximately 200 atmospheres for the running of commercial vehicles with high speed internal combustion engines.

Since this earlier work referred to was carried out, considerable developments in the use of Gas for Industrial Heating have taken place, not only in this country, but also in America and on the Continent.

The development in Birmingham is best shown by the fact that the increase in output of Gas used for industrial purposes alone is no less than 2600 millions, the consumption of Gas used for this purpose for the year ended March, 1913, being 609 millions, whilst for the year ended March, 1930, no less than 3210 million c.ft. were supplied, representing an increase of over 500 per cent.

In America, the huge development in the use of Gas for industrial processes is indicated by the ever-increasing outputs of the leading Gas Undertakings, and in Germany, the recent developments in the transmission of Coke Oven gas over long distances are an indication of the realization of the advantages to be obtained by the use of this form of fuel.

In our own country, we have the developments which have taken place in districts where Coke Oven gas is available, and the ever-increasing demand for this form of fuel in districts where it can be obtained at comparatively low prices confirms that the manufacturer has at last fully realized the many advantages of gaseous firing of his industrial plant, as compared with solid fuel which has hitherto been employed for this purpose.

In many industrial areas where the development in the use of Gas is proceeding rapidly, Town's gas is now being used in preference to other forms of fuel for large-scale industrial heating processes.

For many years, for such operations, Town's gas was looked upon as an expensive fuel by reason of its comparatively high B.Th.U. cost, but a closer study on the part of the user has demonstrated that for many operations the comparatively high B.Th.U. cost is more than justified owing to the savings incidental to its use.

In most heating operations the very high efficiency of utilization of this form of fuel is at once apparent, and the reduction of the all-in costs, brought about by the use of Town's gas as compared with other forms of fuel, has, in some instances, been greater than the fuel cost of the operation itself.

The many advantages of Town's gas as an industrial fuel are now too well-known to need recapitulating, but it may be well to mention one or two which have perhaps not always received the consideration deserved. These are:—

(1) Town's gas is essentially a fuel which can be efficiently burned under controlled conditions and so makes available a very wide range of atmospheres within the working chamber.

(2) Town's gas readily lends itself to automatic control, and owing to its high thermal concentration, it can be distributed through pipes of comparatively small section to different points in a manufacturing establishment at a comparatively low cost.

(3) Owing to the high flame temperatures which can be obtained, it is possible to transfer heat very rapidly to the load. This condition is essential where a particular heating operation demands a high rate of throughput. Further, owing to the relatively high thermal capacity of the air used for its combustion, the working temperatures can be elevated by simple recuperation.

During the last few years the development in the use of Gas industrially has been due rather to improved efficiencies of furnace plant than to reduction in the thermal cost of Gas, but at the present time, owing to most Gas Undertakings appreciating the advantage of an industrial load, special rates are being offered for Gas used for this purpose, and this encouragement, coupled with still further improved efficiencies of plant which are now available, enables most heating operations to be carried out by Gas in economic relationship to other forms of fuel, many of which, though low in cost on a B.Th.U. basis, have a correspondingly low efficiency of utilization.

It is proposed to refer in Chapter I. to the thermal exchanges which take place during the process of combustion of Gas in furnaces of modern design, with special reference to those factors which govern the extent to which the sensible heat evolved by combustion can be employed usefully in heating the load, and in later chapters to a number of important practical applications, giving details of the performances which might be reasonably expected with furnace plant of modern design.

The Author would like to express his indebtedness to the Chairman and members of the Gas Committee of the Birmingham Corporation; and to the General Manager and Secretary of the Birmingham Gas Department (Mr. A. W. Smith), for granting permission to publish this information.

Thanks are also due to Mr. H. R. Hems for the assistance he has given in the compilation of this Paper, and to Dr. J. S. Clarke, who has been responsible for the carrying out of the engine tests referred to and for the design of the special air/gas mixer described.

In addition, the Author would express his gratitude to the various Gas Undertakings and Firms who have so willingly supplied certain photographs and drawings referred to in this Paper.

SECTION I.

INDUSTRIAL HEATING.

I. THERMO-DYNAMIC CONSIDERATION OF COMBUSTION AND ITS RELATIONSHIP TO WASTE HEAT RECOVERY.

A Paper dealing with the economics of fuel utilization would be incomplete without particular reference to the

[1] "Notes on Gaseous Heating," by E. W. Smith and C. M. Walter. Journal of Gas Lighting, 24th June, 1913, page 958.

methods of recovering heat from the waste gases by recuperation or regeneration, thereby increasing that percentage of heat liberated in the working chamber which is given up to the load and resulting in an increase of the efficiency of heat utilization.

The recovery of waste heat may be carried out by either:—

(*a*) Regeneration or recuperation of the air utilized for the combustion of the gas, or

(*b*) The pre-heating of the load prior to its being raised to the working temperature.

Whichever method is adopted, the principle involved is the same, in so far as a certain percentage of the sensible heat of the waste gases which would otherwise become unavailable is transferred to the load, either directly in the case of load recuperation, or indirectly in the case of regeneration or recuperation. The sensible heat so conserved is thus transferred to the combustible mixture, elevating the flame temperature and therefore increasing the Heat Transfer Potential.

Heat Transfer Potential.

It will perhaps, at this juncture, be well to define clearly the expression "Heat Transfer Potential." By this is meant the slope between the temperature of the gases undergoing combustion and the temperature of the Charge T. It will be understood that the efficiency of heat transfer is directly proportional to this slope, which can be expressed as the difference of the temperature $T_1 - T$.

Specific Heats.

From a knowledge of the specific heats of gases, it is possible to calculate the theoretical combustion temperature of any gas or gaseous mixture. By this means, it is possible to deduce the theoretical efficiency of any furnace on similar lines to the heat engine.

The specific heats of the gases are a function of temperature and take the following form:

$$K_p = b + S_1 T + S_2 T^2 + \ldots$$
$$K_v = a + S_1 T + S_2 T^2 + \ldots$$

Heat Addition and Rejection.

The heat addition in the furnace is at constant pressure and can be expressed by the following equation:

$$\text{Heat added} = \int_{T_0}^{T_1} (b + S_1 T + S_2 T^2 + \ldots)\, dT$$
$$= b(T_1 - T_0) + \frac{S_1}{2}(T_1^2 - T_0^2) + \frac{S_2}{3}(T_1^3 - T_0^3),$$

where T_1 is the combustion temperature and T_0 is the initial temperature of the charge.

The equation can be easily solved for T_1 by trial and error. Similarly, the heat rejected from the furnace at any temperature T

$$= \int_{T_0}^{T} K_p\, dT = \int_{T_0}^{T} (b + S_1 T + S_2 T^2)\, dT.$$

It should be remembered, however, that the constants for the specific heats are in this case for the products of combustion only.

Efficiency of Furnace.

The foregoing equations show that the efficiency of the furnace, that is—

$$\frac{\text{Heat added} - \text{Heat rejected}}{\text{Heat added}}$$

is a function of temperature, and can be expressed in the following form:

$$\text{Efficiency} = \frac{T_1 - T}{T_1}.$$

This expression is purely theoretical and does not take into account the thermal capacity of the refractories. From this we see, as would be expected, that for the efficiency to be a maximum, the temperature gradient between the combustion temperature and the load must be a maximum, and conversely that the efficiency would be zero when $T = T_1$.

To investigate the properties of the foregoing equations, let us take two gases of marked difference in composition, namely, Town's gas and Producer gas. Taking a typical analysis of Producer gas, the specific heat of the sum of the constituent gases of the products of combustion of 1 c.ft. of Producer gas + theoretical air is given by the following equation:

$$K_p = 0.0618 + \frac{1.831}{10^5} T - \frac{0.1665}{10^8} T^2.$$

The calculated C.V. of the gas = 140·25 B.Th.U. per c.ft. dry, at N.T.P. The combustion temperature can now be calculated from the equation shown previously:

$$140.25 = 0.06187 (T_1 - 273) + \frac{0.9155}{10^5} (T_1 - 273)(T_1 + 273)$$
$$- \frac{0.0555}{10^8} (T_1^3 - 273^3).$$

Solving this equation T_1 = 1940° C. abs. = 1667° C. This is the theoretical combustion and does not take into account any heat loss. In the case of an average Town's gas, the theoretical combustion temperature is approximately 2200° C.

If now we consider any furnace operation, where the temperature of the work is at, say, 760° C., then the heat transfer potential for Producer gas is 1667 − 760 = 907° C., and for Town's gas 2200 − 760 = 1440° C.

It is apparent that there is an increase in the heat

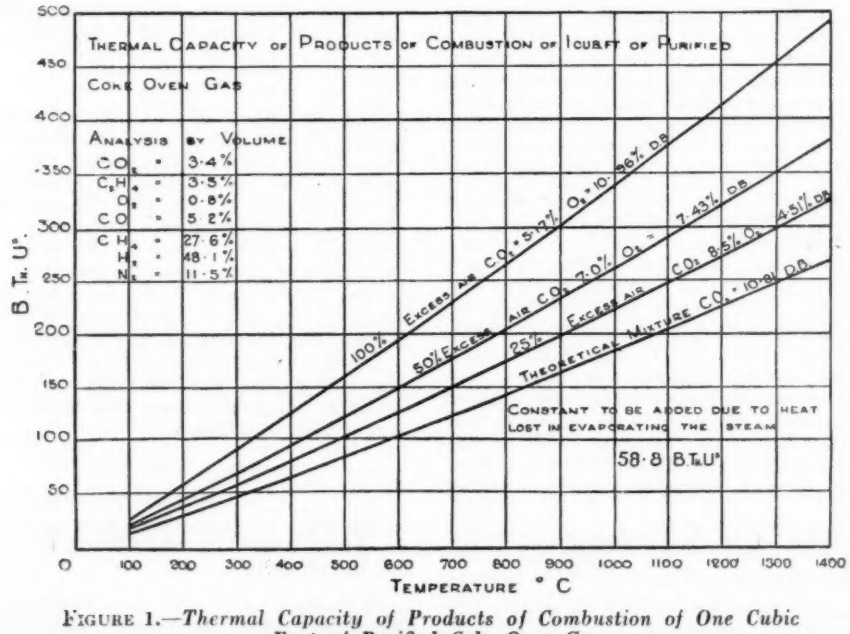


FIGURE 1.—*Thermal Capacity of Products of Combustion of One Cubic Foot of Purified Coke Oven Gas.*

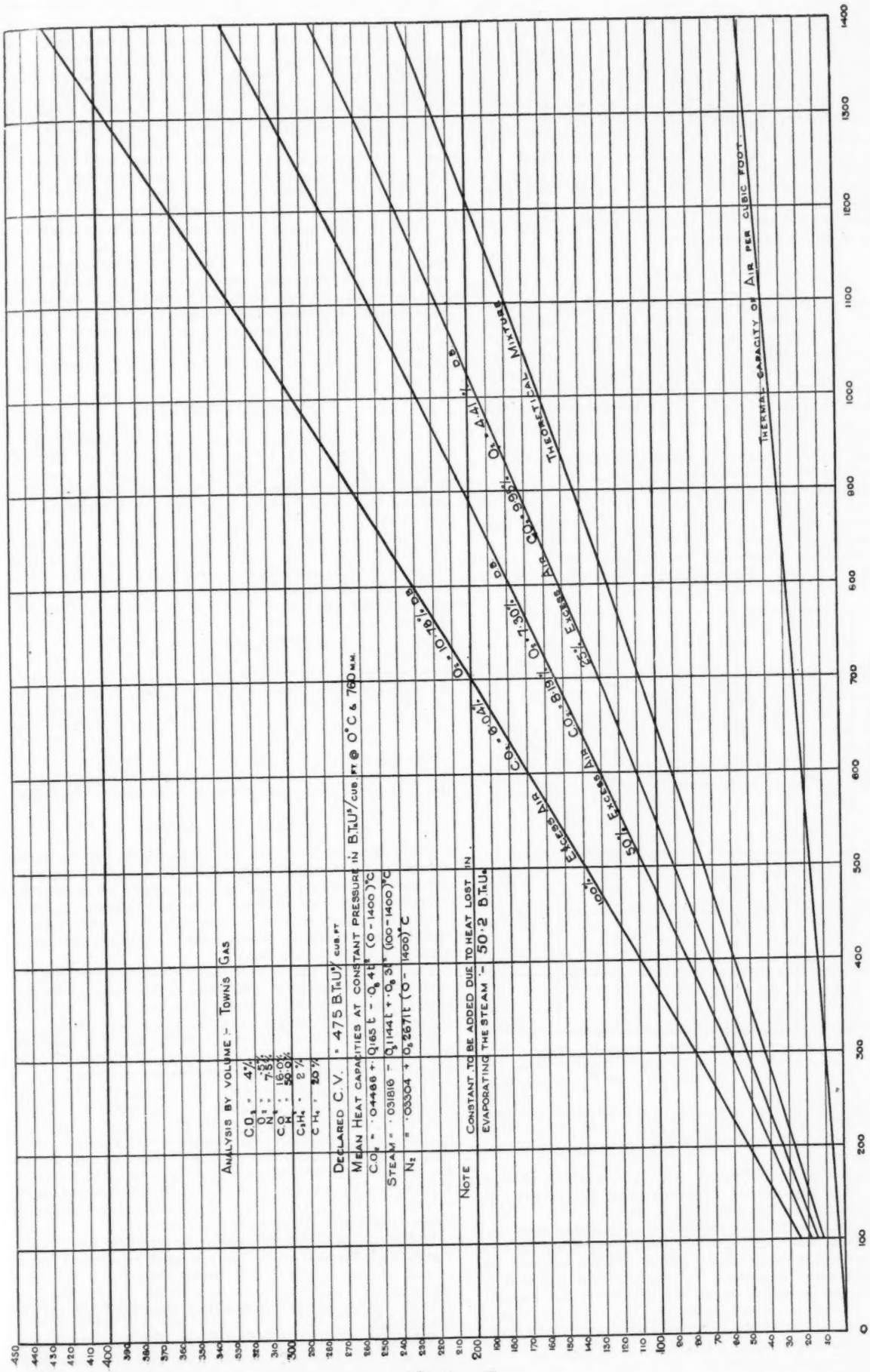


FIGURE 2.—*Thermal Capacity of Products of Combustion of One Cubic Foot of Town's Gas.*

transfer potential for Town's gas over Producer gas, the amount being 1440 − 907 = 533° C.

From the results of tests on a furnace using Town's gas and Producer gas, it was found that the heat input per lb. of load = 1287 B.Th.U. was required when using Producer gas, as against 886 B.Th.U. per lb. of load in the case of Town's gas. The furnace was working under similar atmosphere conditions and rate of output. There is thus a decrease in the B.Th.U. required of 401 B.Th.U. or 31·1 per cent. This practical result corroborates the theoretical and shows the importance of having a gas for industrial operations which will give a high flame temperature.

It has been shown that the heat rejected from the furnace at any temperature T

$$= \int_{T_o}^{T} K_p \, dT.$$

and curves have been prepared showing the thermal capacity at various temperatures T and combustion conditions. Figure 2 shows the curves for Town's gas. For any temperature T or furnace atmosphere, the corresponding thermal capacity of the products of combustion can be read off. It will be noticed that the thermal capacities are given in B.Th.U. for the products of combustion of 1 c.ft. of gas + various proportions of air for combustion.

On the same diagram the thermal capacity of air per c.ft. at different temperatures is shown.

Similar curves for the products of combustion of Coke Oven gas are given in Figure 1.

From an examination of the curves it is obvious that the combustion efficiency is lowered by the addition of excess air, as it is seen that the thermal capacity of the products increases. Figure 3 shows the variation of the

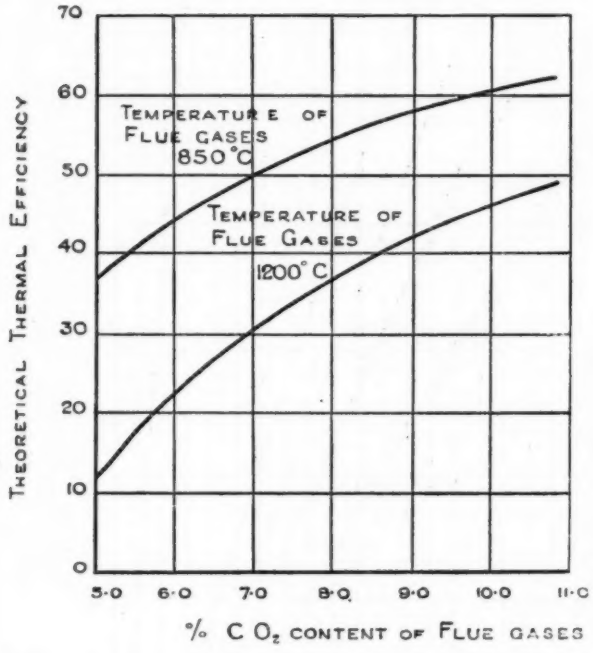


FIGURE 3.—*Curve showing Variation of Theoretical Thermal Efficiency with CO_2 content of Flue Gases. Purified Coke Oven Gas.*

theoretical thermal efficiency with CO_2 content of flue gases. The importance of maintaining the furnace at maximum combustion efficiency is seen.

It has been stated previously that a method of recovery of heat from the waste gases is used for preheating the air or gas before combustion. If we refer a moment to the fundamental equation, the sensible heat S which is added to the fuel itself or the air utilized in its combustion,

$$H + S = \int_{T_o}^{T_1} (b + S_1 T + S_2 T^2 +) \, dT,$$

will result in raising the flame temperature of the gases during combustion, thereby increasing the heat flow potential and therefore the efficiency.

We will now consider to what extent the conditions under which an actual furnace operates in practice approach the ideal. In the first place, from theoretical considerations, we have assumed that combustion takes place without any loss of heat. In practice, this is by no means the case, for in the actual furnace, owing to the fact that combustion is not instantaneous, during the period in which it takes place heat is given up from the flame, both by radiation and conduction, to its surroundings. Thus the flame temperature possible in practice is lower than that obtained from theoretical calculations.

Then we have assumed that under the ideal condition the combustion efficiency is a maximum, that is to say, only the theoretical amount of air required for combustion is utilized. Fortunately, with many of the modern designs of furnaces now used for quite a large variety of heat-treatment processes, the combustion efficiency, even over a very wide range of working temperatures, can be maintained at a high standard. In other words, the amount of excess air used does not exceed, in many instances, 10 per cent.

Recuperative Efficiency.

In order to remove all the sensible heat from the products of combustion by air recuperation, the thermal capacity of the air required for combustion must be equal to the thermal capacity of the waste products. The ratio of the amount of heat the air for combustion can absorb, to the amount of heat in the flue products is defined as the Recuperative Efficiency. This ratio has been evaluated for various gases for an equivalent heating value, and the results are shown plotted in Figure 4. The results illustrate that for gases with a low air/gas ratio, only a small amount of heat can be extracted from the flue products, due to the low thermal capacity of the air required for combustion. For Town's gas, the recuperative efficiency is 82·5 per cent. against 51 per cent. for Producer gas. This results in an increase in the overall thermal efficiency for the Town's gas-fired furnace. In practice, this would mean that where simple regeneration or recuperation would suffice in the case of Town's gas-fired furnaces, it would be necessary to employ double recuperation, *i.e.*, recuperation by air and gas with some of the lower grade gases, if a reasonable percentage of the heat in the waste gases is to be recovered in this way.

Thermal Concentration.

From the above, it will be apparent that in order to obtain a high thermal concentration, a high flame temperature is necessary. In many processes where a comparatively high rate of throughput is required, heat has to be transferred to the load very rapidly, and thus, a high thermal concentration is essential if the load is to be heated in a reasonable time.

The degree to which heat can be concentrated in the combustion chamber will to some extent depend on the type of burner employed and on the degree to which the air used for the combustion of the gas is pre-heated.

Other factors, however, which enter into this question include, in particular, the velocity at which the air/gas mixture is projected into the combustion chamber.

It may be of interest to note that in the case of modern designs of furnaces operating on the natural draught principle, such as would be employed for re-heating, carburizing, and general heat-treatment work, a thermal concentration approximating to the release of ·75 therm per c.ft. of free combustion space per hour is possible. Further, in the case of furnaces of this design the usual velocity of the gas entering the combustion chamber varies from two to three metres per second.

In the case of high temperature forging furnaces, where a very high thermal concentration must be allowed for, a release of approximately 1·5 therms per c.ft. of free combustion space per hour is possible, with a corresponding velocity of gas into the combustion chamber of 30 metres per second.

Where the combustion is delayed, it is usually associated with low thermal concentration and low flame temperature, which condition may be desirable for certain types of heat-treatment work where a high degree of con-

centration of combustion is not only unnecessary but inadvisable.

Furnace Efficiencies and Thermal Balances.

In view of the importance of clearly defining furnace efficiency, it will be well to consider, in the first place, the relationship between the thermal efficiency of the heating operation and the thermal efficiency of the furnace itself.

When heat generated in the combustion chamber of a furnace is utilized in doing useful work, part of the sensible heat so produced passes into the load to be heated, part is utilized in heating up the brickwork and other material of the furnace itself, part is given up by radiation, convection and conduction from the outside walls, and the balance is carried away by the products of combustion.

The thermal efficiency of the heating operation must, of course, refer to the ratio of the amount of heat employed in doing useful work, to the heat which has to be paid for—i.e., B.Th.U. utilized in raising the load over the B.Th.U. supplied in the form of gas.

This figure of efficiency, as will be understood readily, is not the same as the thermal efficiency of the furnace itself, which latter may be defined by the following ratio:

$$\frac{\text{Total sensible heat absorbed in the working chamber}}{\text{Total heat dissipated in the working chamber}}$$

As an example of the improvement in thermal efficiency of furnaces which have been obtained during the last few years, the Author now intends to describe a heating process in which the scientific control of combustion has led to a considerable reduction in the working costs and a consequent improvement in thermal efficiency.

The application referred to in this case relates to the carburizing of steel components in recuperative furnaces of the natural draught type fitted with automatic control of both gas and air used for combustion.

A considerable amount of information has already been published[2] in connection with performances of furnaces of this type for similar processes, but in view of the fact that this type of furnace lends itself particularly well to the evaluation of a thermal balance, it would perhaps be of interest to examine briefly some average results which have been obtained from such a furnace.

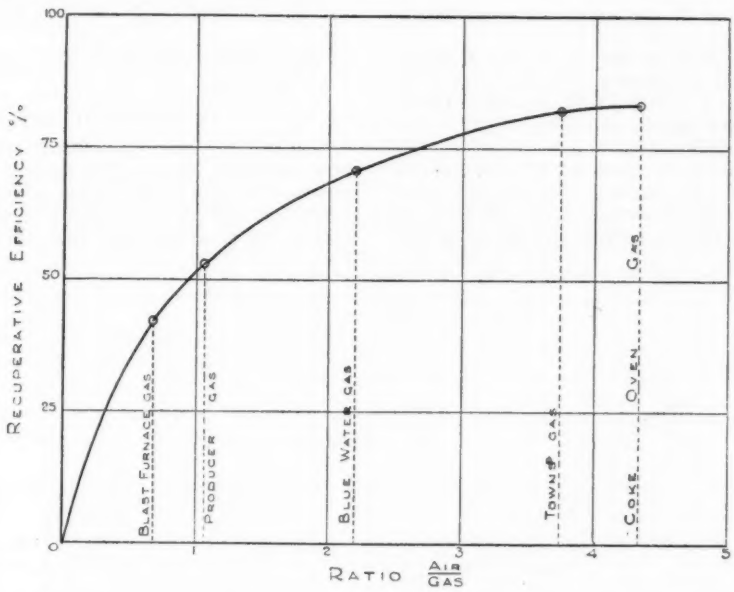


FIGURE 4.—*Theoretical Recuperative Efficiency of Different Gases for Equivalent Heating Value for Theoretical Mixture at* 1000° *C.*

Table I. shows the overall results of six consecutive loadings, with the corresponding gas consumptions and average gas rates.

In order to complete a heat balance, it is necessary to know:

(1) The amount of heat required to bring the load to a certain temperature.
(2) The thermal capacity of the charge.
(3) The determination of the amount of heat carried away by the products of combustion.

(1) *The amount of heat required to bring the load to a certain temperature.*—The amount of heat required to bring the load to a certain temperature is by far the most difficult quantity to determine. A possible method would be to have numerous thermo-couples inserted in the carburizing pots at different distances from the surface. This method was not used in this instance, however, but instead, hourly gas consumptions were taken from the time the charge was put into the furnace. A typical result is shown plotted in Figure 5. It is assumed that, when the gradient of the curve becomes constant, the charge has become thoroughly soaked. It will be noticed from the curve that this took approximately five hours,

TABLE I.—*Showing the Overall Results of Six Consecutive Loadings, with the Corresponding Gas Consumptions and Average Gas Rates.*

Heat No.	Total Time of Heat. Hrs.	Mins.	Total Gas Consumption. C.Ft.	Average Gas Rate. C.Ft. per Hour.	Total Weight of Heat. Lbs.	Gas Consumption. C.Ft. per Lb. of Work.	Depth of Case.
1	2		3	4	5	6	7
1	10	15	5157	504	2680	1·937	1/32 in.
2	12	35	5720	455	2929	1·95	,,
3	11	21	4525	400	2331	1·95	,,
4	24	55	8990	361	2143	4·19	1/16–5/64 in.
5	10	40	4542	426	2682	1·69	1/32 in.
6	10	40	4423	416	2744	1·614	,,

2. "The Utilisation of Town's Gas as a Fuel in Heat Treatment Furnaces." By C. M. Walter, D.Sc. Journal of the Institute of Fuel, Vol. III. No. 12. July, 1930.

and that the time was fairly constant for all experiments. The amount of gas consumed up to the " change point " can be taken as that required to bring the load up to temperature, the balance being necessary to maintain the furnace and charge at the temperature.

(2) *The thermal capacity of the charge.*—The thermal capacity of the charge includes the thermal capacity of the work, pots and carburizing compound. Experiments were made with various pots to determine the percentage of steel and compound. The following are the average results:

Proportion of compound 21 per cent., and steel 79 per cent.

The total heat of the steel at 920° C. is 273 B.Th.U. per lb. If the compound be taken as charcoal, the total heat at this temperature is 591 B.Th.U. per lb. Therefore, the thermal capacity per lb. of charge = ·21 × 591 + ·79 × 273 = 340 B.Th.U. per lb.

(3) *The determination of the amount of heat carried away by the products of combustion.*—The determination of the amount of heat carried away by the products of combustion is made by taking frequent analyses of the products, and taking the temperature as near to the outlet of the recuperator as possible.

The following particulars relate to Heat No. 1 (Table I.). Quantity of gas required to bring load to 920° C. (as given by the " change point ") = 3035 c.ft.

Weight of load	= 2680 lbs.
Consumption per lb. to bring charge to 920° C.	= 1·13 c.ft.
Overall consumption per lb. during process	= 1·937 ,,
Consumption per lb. required to maintain conditions	= 0·807 ,,
Average analyses of flue products— CO_2	= 11·8 per cent.
O_2	= 2·7 ,,
Average temperature of flue products	= 340° C.

The heat balance for 1 lb. of load can be shown in two parts:

(1) The heating up period.
(2) The heating up and maintaining period.

(1) *The Heating up Period.*

Heat supplied per lb. of load to raise to 920° C. = 1·13 × 475 = 536 B.Th.U.	= 100 per cent.
Heat required to bring 1 lb. of load to 920° C. = 340 B.Th.U.	= 63·4 ,,
Heat carried away by flue products = 113·8 B.Th.U.	= 21·2 ,,
Heat lost by radiation, &c., by difference = 82·2 B.Th.U.	= 15·3 ,,

(2) *The Heating up and Maintaining Period.*

Total heat supplied per lb. of load = 1·937 × 475 = 920 B.Th.U.	= 100 per cent.
Heat required to bring 1 lb. of load to temperature (920° C.) = 340 B.Th.U.	= 37 ,,
Heat lost by radiation, &c., during heating up = 82·2 B.Th.U.	= 8·95 ,,
Heat lost by radiation, &c., during maintaining period = 0·807 × 475 − 81·3 = 302 B.Th.U.	= 32 84 ,,
Heat carried away by flue products = 100·7 × 1·937 = 195 B.Th.U.	= 21·2 ,,

II. PRACTICAL APPLICATIONS.

Some of the more important practical applications are now outlined, and at the same time in each particular process the gas consumption which might be reasonably expected with furnace plant of modern design is indicated. It is understood that the calorific value of the gas used approximates to 475 B.Th.U. per c.ft. gross. The figures referred to are set out in Table II.

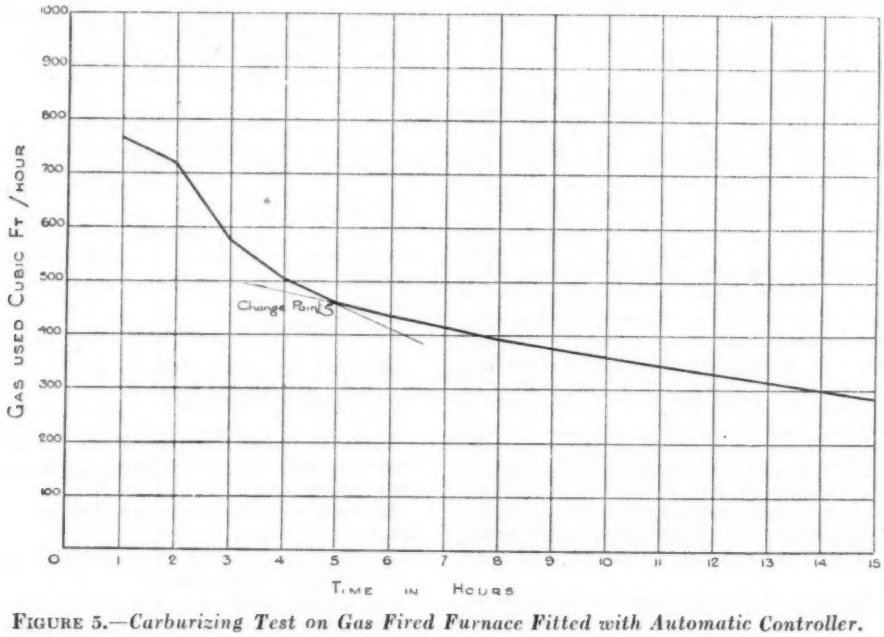


FIGURE 5.—*Carburizing Test on Gas Fired Furnace Fitted with Automatic Controller.*

1. *Carburizing.*

In the majority of operations calling for the cementation or carburizing of steel, the process is usually of a continuous nature, in so far as the load has to be soaked for considerable periods, and it is therefore usual for furnaces of high thermal capacity to be employed for this work.

With modern types of carburizing furnaces operating on the natural draught principle, and with waste heat recuperation for operations demanding temperatures of about 900 to 920° C., gas consumptions as low as 1·6 c.ft. per pound of gross load have been obtained, but for average work of this nature, a figure of about 2 to 2·2 c.ft. per pound should be allowed for. In the case of intermittent working, where the load is allowed to cool down in the furnace after each soaking operation, this figure would be increased to from 5 to 6 c.ft. per gross pound of load. This comparatively low consumption would apply only in cases where the depth of case required demanded a soaking period of about 10 hours.

2. *Re-heating of Ferrous and Non-Ferrous Materials.*

For the re-heating, normalizing and annealing of steel forgings, finished components and carburized work, natural draught furnaces are eminently suitable, more

especially owing to the ease with which the atmosphere within the working chamber is under complete control.

For this class of work, with working temperatures of 850° to 900° C., a good average figure of gas consumption would be 1·5 to 1·75 c.ft. per pound, but in the case of continuous operation, this figure might, in certain instances, be reduced to as low as 1·2 c.ft.

In the case of non-ferrous material, for the annealing of brass, temperatures ranging from 600 to 700° C., a gas consumption of ·6 to ·7 c.ft. per pound may be taken as an average figure, whilst in the case of annealing of brass pressings and spinnings, this figure would be increased to about 1·4 to 1·5 c.ft. per pound.

When annealing copper in water-sealed furnaces at a temperature of approximately 500° C., a gas consumption of about 1 to 1·2 c.ft. per pound is required.

3. *Metal Melting.*

Town's gas is now employed to a very considerable extent for the melting of white metals, including alloys used for die casting, type metal, bearing metals, and also in connection with the melting of aluminium alloys used so extensively for the production of die castings. Brass, gunmetal, copper, and nickel can also be satisfactorily melted.

Taking type metal as an example, this can be melted at a figure of 700 c.ft. per ton with a furnace operating continuously. Aluminium is melted in the open hearth type of furnace at about 3 c.ft. per pound, and brass in crucibles at a figure of 5 c.ft. per pound, the figure for nickel being over 10 c.ft. per pound and varying according to the quantity melted.

4. *Japanning and Drying Operations.*

Gas is being used more widely than ever previously in the carrying out of drying and japanning operations such as are required for the motor and cycle industries, tin box printing, &c., and also for the drying of cores.

The ordinary " in and out " or batch type of stove is being rapidly replaced by the conveyor type, with separate air heater, and it is interesting to note that several large installations of the latter type of stove, designed and installed for fuels other than Town's gas, have been converted to gaseous heating, owing to the extremely heavy maintenance costs which were found previously to obtain in practice.

The development of the future seems to lie with the recirculation of heated air allowing for the removal of foreign matter taken up by the air stream in carrying out its work in the stove.

5. *Food Production.*

Gas is being used in the production of foodstuffs to an extent which is rarely realized, and this field of applications offers still wider possibilities in the future. In the case of the baking of bread, gas has not yet played its full part where small scale production is demanded, but it has been very widely adopted by engineers designing baking machines for large scale bread baking production, owing to its cleanliness and controllability.

A large number of installations of baking ovens are in use for the production of cake and confectionery. In connection with biscuit production, practically the whole of the large travelling ovens used for the continuous baking of biscuits are gas heated.

The boiling of sugar and making of confectionery and the cooking of meats, are other fields in which gas is used very widely. The cooking of the potato crisp is carried out by gas to the exclusion of practically all other forms of fuel.

6. *Forging.*

In connection with the forging of steel bar and billets Town's gas and Coke Oven gas are now being very extensively used, both for the production of small forgings weighing but a few pounds and for large forgings weighing several tons. In the case of intermittent forging operations, where temperatures up to 1400° C. are required, a gas consumption of approximately 5 c.ft. per pound is an average figure. In the case of the larger forges, working continuously, this figure can be reduced readily to about one half, whilst in the case of furnaces, dealing with very large billets, figures as low as 1·8 c.ft. per pound have been obtained.

In the latter case, furnaces of the regenerative type are often employed on account of the ease with which the high temperatures required can be maintained with a high rate of throughput, and also in view of the increase in thermal efficiency resulting from this type of furnace.

TABLE II.—*Showing probable Gas Consumption and other details of various Heating Processes.*

Heating Process.	Grade of Gas Employed.	Temperature Range.	Type of Furnace.	Thermal Efficiency of Heat Application Expressed as Heat in Load/Heat Supplied.	Gas Consumption.	
					C.Ft. per Ton.	Therms per Ton.
1	2	3	4	5	6	7
		°C.		Per Cent.		
Forging	Town's gas 475-500 B.Th.U. per c.ft.	1100–1250	Reversing regenerative	37–40	4500	21·5
Forging	Town's gas 475 B.Th.U. per c.ft.	1250–1300	Small direct fired	20–25	7600	36
Forging	Town's gas 475 B.Th.U. per c.ft.	1250	With recuperation	26–30	5200	25
Re-heating . . .	Town's gas 475 B.Th.U. per c.ft.	780	With partial recuperation	32–34	3150	15
Re-heating . . .	Town's gas 475 B.Th.U. per c.ft.	900	With partial recuperation	30	3900	18·5
Billet heating . .	Town's gas 475	950	Load recuperation	24	5250	25
Large billet heating.	Coke oven gas 485	950	Recuperation by air and load regeneration	40	3100	15

7. *Central Heating.*

The demand for a fuel which does not require storage capacity and which can be handled automatically, to replace forms of fuel hitherto employed for the central heating of large buildings, offices, and other establishments, has resulted in Town's gas being employed to a very considerable extent for this purpose. Already, in many parts of the country, we have examples of large installations of automatically-controlled Town's gas-fired heating boilers.

With some of the more recently designed apparatus now available, efficiencies as high as 80 per cent. can be realized and where Town's gas can be obtained at a cost approximating to 4d. per therm, it is generally found that this form of fuel can compete favourably with other fuels.

III. ECONOMIC VALUES OF FUEL.

From the foregoing sections it will be apparent that for many industrial processes carried out in districts situated at some distance from coal producing areas, the economic value of Gas will be in many instances considerably greater on a thermal basis than the cost of solid and other forms of fuel.

By the economic value of a fuel is meant the cost per therm which would justify its adoption in place of other forms of fuels available at average market prices. Thus, it will be seen that the economic value of Gas as a fuel, by reason of its greater efficiency of utilization and the

incidental savings brought about by its application, might easily be several times the cost of solid fuel.

From general experience which has been obtained in various parts of the country, it would appear further that if Gas Undertakings supplying large industrial consumers are in a position to justify rates as low as 4d. per therm, there is a very considerable field open for the development of new business, even where competition from other sources is being experienced. In other words, at the present time, the economic value of Town's gas for a large number of industrial heating operations corresponds with this figure.

With regard to coke oven gas, it will be realized that at present, so far as this country is concerned, coke oven gas is only available in the vicinity of some of the principal coal producing districts, where, in many instances, solid fuel can be procured at figures as low as 5d. per therm, including service costs. In many of the manufacturing operations carried out in these districts, it is not necessary for the furnace plant to be operated within very fine limits of temperature control; further, it is not always essential that the fuel should be free from impurities. In such cases the economic value of coke oven gas would be from 2 to 2½ times the cost of solid fuel. That is to say, for these particular operations, where unpurified coke oven gas can be supplied at prices round about 1½d. per therm, its employment would be fully justified in place of solid fuel.

Referring to other processes where temperatures must be maintained within close limits and where furnace atmospheres must be under complete control and free from contaminating impurities, the economic value would be, in the special circumstances referred to, 3 to 5 times the cost of coal. From this it will be understood that in the case of purified coke oven gas for many special heat-treatment operations demanding conditions as mentioned above, a cost of 2d. to 3d. per therm would be easily justified.

SECTION II.

THE APPLICATION OF TOWN'S GAS TO HIGH SPEED INTERNAL COMBUSTION ENGINES.

IV. OUTLINE OF THE PRESENT POSITION.

The second Section of this Paper deals with an application of Town's gas which has recently evoked a great deal of interest from many of the large Gas Undertakings, both in this country and on the Continent, viz., the use of gas stored at very high pressures, in steel bottles, as a fuel for high speed internal combustion engines.

The idea of using Town's gas as a fuel for high speed engines is by no means new, as it is well known that for some considerable time this form of fuel has been employed by many of the leading motor manufacturers for " running-in " their engines. Further, during the period of the War, Town's gas was used to a very considerable extent for the propulsion of vehicles primarily designed to run on petrol, the gas being contained in large flexible bags usually housed on the roof of the vehicle. The results of tests carried out at that time proved, without doubt, that satisfactory results could be obtained, and further, that the thermal efficiency realized was of a high order. The main difficulty which presented itself was the somewhat limited capacity of the storage, which resulted in the radius of action of the vehicle being somewhat restricted.

It will be further recalled that in both Blackpool and Manchester certain sections of the tramway systems were operated, many years ago, by internal combustion engines using as a fuel Town's gas stored in containers at relatively low pressures.

Until quite recently, it was also found that the storage of gas in the compressed form in steel cylinders or bottles, was impracticable, owing to the weight of such containers being so great as to add materially to the dead weight of the vehicles to be propelled. At the present time, owing to the advances which have taken place, particularly in regard to the manufacture of high tensile alloy steels, bottles can be produced of this material, which, after suitable heat-treatment, have such a high tensile strength as to enable them to be employed for the storage of gas under very high pressures, and which at the same time are only a fraction of the weight of the containers hitherto employed for this purpose.

In view of this, it is now proposed to employ steel bottles of this material for the storage of gas on vehicles at a pressure approximating to 200 atmospheres.

In Paris, during the last few years, a considerable amount of experimental work has been carried out in connection with the running of passenger-carrying and other vehicles with Town's gas stored in this manner, the storage bottles in this case being made of heat-treated nickel-chrome steel, and having a weight of only 60 per cent. of that of the ordinary steel bottles usually employed for gas storage at these elevated pressures. The results of these experiments seem to have proved, beyond doubt, that under certain conditions, Town's gas can be utilized for the running of certain types of heavy motor vehicles with definite advantage as compared with petrol. It is also understood that, as a result of these experiments and owing to the many advantages, a considerable number of heavy refuse collection vehicles are to be fitted with Town's gas equipment.

In a paper entitled " L'Utilization du Gaz de Ville à la Traction Automobile," by M. A. Pignot,[3] the results of this experimental work are published in detail, and some very useful information in regard to the properties of gases at these high pressures is recorded in this treatise.

Some few months ago, the Author had the opportunity of inspecting, in Paris, a number of the vehicles referred to above, to ascertain the conditions under which they were operating, and also to investigate fully the possibilities of the use of Gas for this purpose. As a result of the information obtained, the Gas Committee of the Birmingham Corporation decided to carry out a series of experiments to inquire fully into the possibilities of Town's gas in the compressed state as a fuel for commercial vehicles.

This investigation is being carried out by the Industrial Research Laboratories of the City of Birmingham Gas Department, and during the last few months the first series of tests on engines has been completed.

The engine tests, results of which are given in detail hereafter, were carried out at one of the 'Bus Depôts of the Birmingham Corporation, where a suitable electrical dynamometer was available.

The cooling water losses were not measured, but the jacket cooling water outlet was fitted with a thermometer close to the engine head, and throughout the whole series of tests the jacket water temperature was kept at a constant figure in order to ensure that the friction losses were also constant.

It will also be noted that two types of air/gas mixers were used during these experiments, one being of the standard injector type which is ordinarily used for the " running-in " of engines, the other being specially designed with a view to obtaining the most intimate mixing of air and gas pressure prior to entering the cylinder.

In this latter design, the gas is caused to pass through a number of small openings arranged at right-angles to the air stream, and is further so arranged that if necessary the gas throttle and air regulator can be inter-connected. A series of drawings of this mixer are shown in Figure 6.

V. RESULTS OF EXPERIMENTAL WORK CARRIED OUT BY THE CITY OF BIRMINGHAM GAS DEPARTMENT.

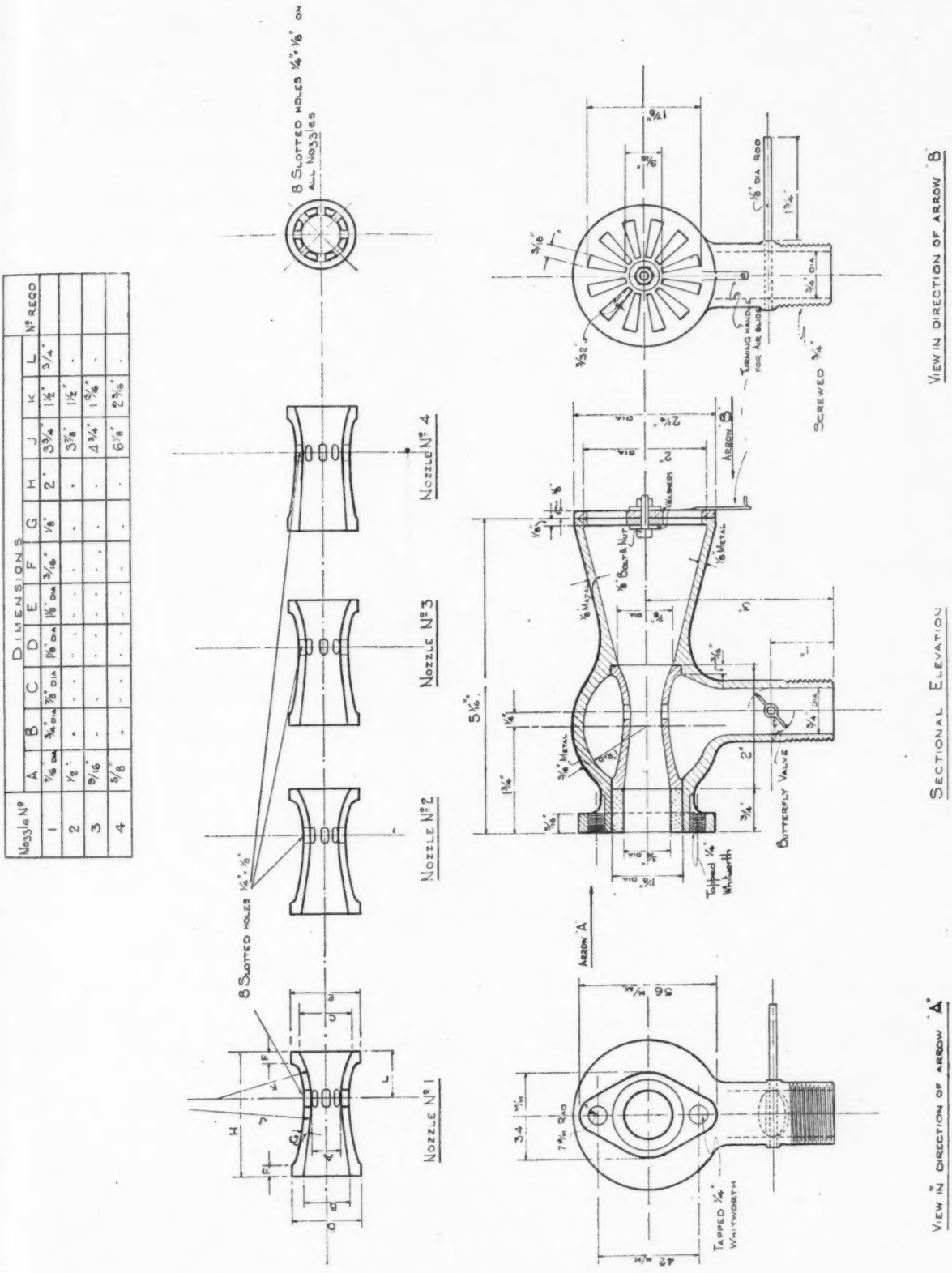
The experiments on engines referred to above were carried out with a view to determining the speed-power and gas consumption characteristics of engines running on Town's gas as compared with the performances obtained when running on Petrol.

These series of tests, which have only been partly completed, have also been arranged with the object of ascertaining the effect of supercharging, and, in the case of gas, carburetting with benzol.

A further series of experiments will be carried out at a later date to determine the effect of alteration of the compression ratio on the maximum power output and thermal efficiency.

The first series of tests were carried out on a 6-cylinder Regent engine over a speed range from 800 r.p.m. to the

[3]. Bulletin of the Société des Ingénieurs Civils de France. July–August, 1930.



No 3 to 6 No	Dimensions												No Reqd
	A	B	C	D	E	F	G	H	J	K	L		
1	5/16 dia	¾" dia	⅞" dia	1⅜" dia	1⅛" dia	3/16"	⅛"	2"	3¾"	1½"	¾"		
2	½"	-	-	-	-	-	-	-	3⅜"	1½"	-		
3	9/16"	-	-	-	-	-	-	-	4 ¾"	1 ⅝"	-		
4	5/8"	-	-	-	-	-	-	-	6⅛"	2 ⅜"	-		

FIGURE 6.—*Gas Mixing Chamber for Internal Combustion Engines.*

maximum which could be obtained from the engine when running on Town's gas.

The results of these tests are shown in Figure 7, from which it will be noted that at about 1000 r.p.m., the power increases very rapidly with the speed, which does not reach a maximum before the running becomes unstable.

The total gas consumption per hour has a similar characteristic to the power curve. The consumption of gas per B.H.P. hour decreases as the speed increases and reaches the minimum at a speed of about 1600 r.p.m. At higher speeds, the gas consumption again increases, due to the decrease in volumetric efficiency, as would be anticipated.

In these tests, a simple form of air/gas mixer was used, and as the gas consumption figures obtained were rather high, it was decided to carry out a further series of experiments with a 4-cylinder A.E.C. engine with both the old type of mixer and the improved type already referred to.

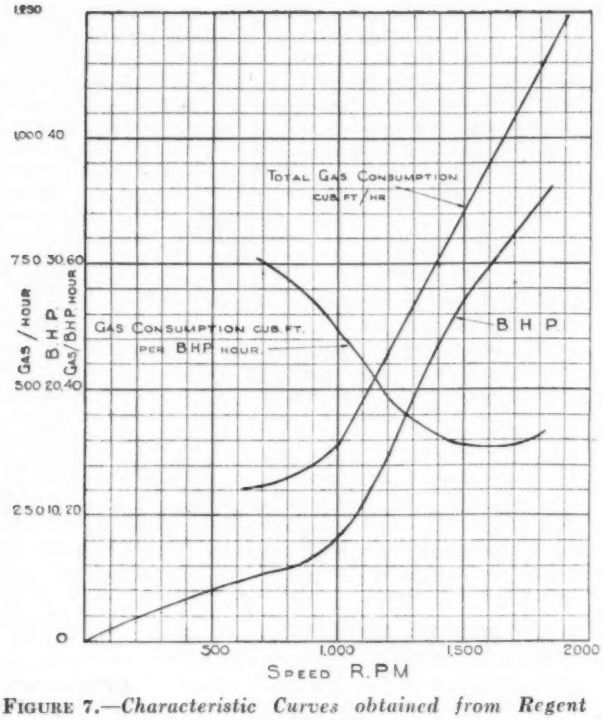


FIGURE 7.—*Characteristic Curves obtained from Regent Engine No.* 19.

The actual mixer used in this case was not sufficiently large to obtain the maximum power output from the engine; thus the improvement in the performance is only partially representative of what could be obtained with a larger unit. The comparative figures obtained from these tests are shown in Table III.

From these results, it will be seen that the engine developed 35 B.H.P. and gave a performance of 27·6 c.ft. per B.H.P. hour with the improved mixer, against 31·9 with the simple type, the reduction in gas consumption amounting to over 100 c.ft. per hour at these power outputs. A special feature of this new design of mixer is its flexibility and responsivity over a wide range of speeds.

The further series of tests carried out on the small 7-horse 4-cylinder engine included the following fuels:

(1) Town's gas alone.
(2) Town's gas with supercharge on the air/gas mixture.
(3) Benzol carburetted Town's gas without supercharging.
(4) Benzol carburetted Town's gas with supercharging.
(5) Petrol without supercharging.
(6) Petrol with supercharging.

The compression ratio of the engine used was 5·5 and the ignition in each test was adjusted to give the maximum speed possible for the particular condition. In order to maintain the mechanical losses in the engine constant, the jacket water was kept at a constant temperature.

Before proceeding to compare the results of the different fuels in detail, it will be interesting to examine Figure 8, which shows the percentage of CO in the exhaust gases when running on petrol. For the lowest speed—approximately 1000 r.p.m.—the CO content of the exhaust gases amounted to 1·4 p.ct., which figure decreases as the speed increases until a speed of 1836 r.p.m. is reached, when the CO content is reduced to nil. Above this speed, there is further evidence of CO in the exhaust gases. Although the engine was fitted with a turbulent head, these results show that there is a considerable amount of burning taking place during the expansion stroke of the engine, even with so volatile a fuel as petrol.

In the case of the tests in which carburetted gas was used, the arrangement of the carburetting tank is shown in Figure 9. The gas was enriched by about 100 B.Th.U. per c.ft. A summary of the tests is given in Table IV. The results for the supercharging tests will be analyzed first. In the present state of design, the most important factor in the development of this work is the proportion of the maximum power obtained from the engine when using

TABLE III.—*Showing Comparative Results of Tests with Two Types of Gas Mixers, on a 4 Cylinder, 5 Type, A.E.C. Engine.*

Speed.	Volts.	Amps.	Watts.	Dynamo Efficiency.	B.H.P.	Gas.		
						C.Ft. per Hour.	Pressure. Ins. H_2O.	C.Ft. B.H.P.-Hour.
1.	2.	3.	4.	5.	6.	7.	8.	9.
GAS MIXER—NEW TYPE.								
1250	165	147	24,200	92·4	35·2	970	3·0	27·6
GAS MIXER—OLD TYPE.								
1250	162	145	23,500	9[illegible]	34·2	1090	3·0	31·9

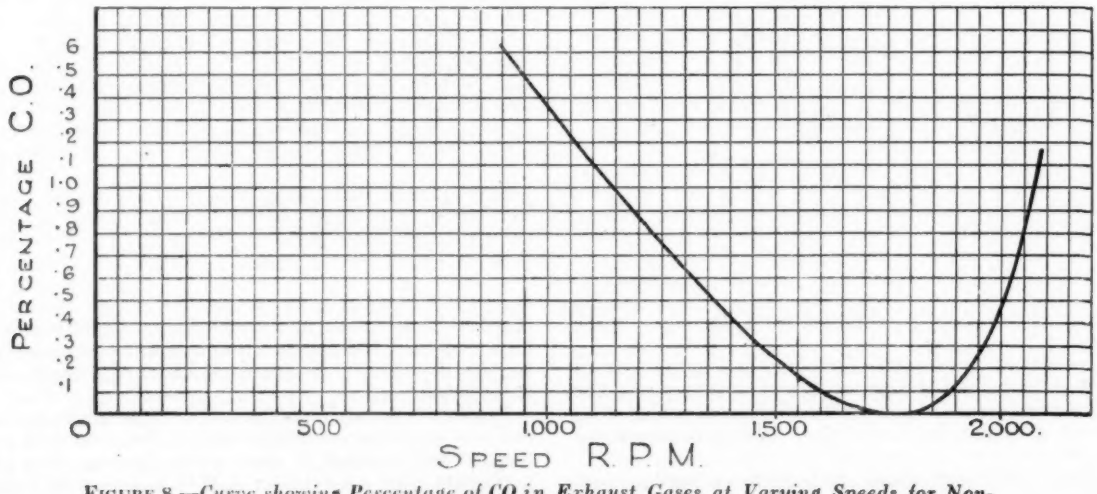


FIGURE 8.—*Curve showing Percentage of CO in Exhaust Gases at Varying Speeds for Non-supercharging Petrol Tests.*

Town's gas compared with petrol. The maximum output on petrol is represented by 100 per cent. and the maximum output on any other fuel is expressed as a percentage of that of petrol.

Referring to Table III., it will be seen that the output for carburetted gas is 86 per cent. of that of petrol, while in the case of gas alone, it is slightly over 72 per cent. This is a very satisfactory figure. The brake thermal efficiency on petrol is very low compared with the results of the other types of fuel. This is corroborated by the results of exhaust gas analyses, the CO

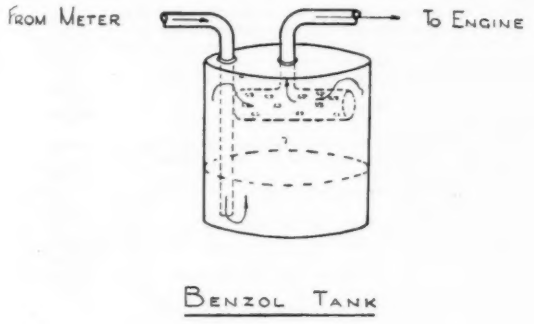


FIGURE 9.—*Showing arrangement of the Carburetting Tank for Benzolizing Gases.*

content being 4·2 per cent. when using petrol compared with 0·7 per cent. when using carburetted gas. The thermal efficiency shows a considerable increase with this form of fuel, the figure being 26 per cent., as compared with 19·35 per cent. with gas alone and 16 per cent. in the case of petrol, showing that the addition of benzine accelerates combustion to an extraordinary extent.

On examining the non-supercharging results, as would be expected the maximum output of the engine is considerably lower. On comparing the output of the engine when run under this condition, when using the different fuels, it will be seen that in the case of Benzine-gas, 80 per cent. of the power output of petrol is obtained, and when using gas alone, this figure drops to 66 per cent. The thermal efficiency on petrol is 22·6 per cent. This is improved to 23·9 per cent. when using Benzine-Town's gas, but it is reduced to 19·6 per cent. with Town's gas alone.

Conclusions.

The conclusions derived from the above results may be summarized as follows:

(1) The thermal efficiency of high speed internal combustion engines when supercharged is greater when using Town's gas than when petrol is used, and is further increased by carburetting the gas with benzol.
(2) The thermal efficiency with petrol as a fuel is decreased by the application of supercharging.
(3) The maximum power developed with gas alone is lower than that obtained with petrol.
(4) The CO content of the exhaust gases is considerably less with Town's gas as a fuel than in the case of petrol.
(5) Gas is more responsive to supercharging than petrol, the power output being increased to a greater extent. This is corroborated by the fact that in the tests referred to with supercharging, the thermal efficiency is only decreased by 0·25 per cent. on Town's gas compared with 6·45 per cent. on petrol.
(6) The thermal efficiency obtained with Town's gas would be further improved by increasing the compression ratio.
(7) The performance of the engine is very much improved by saturating the gas with benzine or benzol, the amount of benzine required being about ¾ of a gallon per 1000 c.ft. of gas.

From the results of the tests given above, it may be assumed that with a standard type of engine having a compression ratio of 5 to 1, one gallon of petrol would give about the same performance under average conditions of running as 265 c.ft. of gas of 475 B.Th.U. per c.ft., this figure being reduced as the compression ratio is increased.

It would also appear that in the case of the gas being carburetted with benzol, this figure would be reduced to about 200 c.ft., the carburetted gas having a calorific value of approximately 575 B.Th.U. per c.ft.

VI. THE COMPRESSING OF GAS TO APPROXIMATELY 200 ATMOSPHERES.

Energy Required for Compressing Gas to 200 Atmospheres.

The energy required for the compression of Town's gas to 200 atmospheres amounts to about 9 h.p. hours per 1000 c.ft. of free gas compressed and delivered, it being

TABLE IV.—*Being a Summary of Tests on a 7 H.P. Engine.*

SUPERCHARGING.

Fuel.	Maximum Speed, R.P.M.	Max. B.H.P.	Ratio—Maximum Output on Fuel. / Maximum Output using Petrol.	Fuel Consumption. Gas, C.Ft. per Hour.	Gas, C.Ft./B.H.P. Hour.	Benzine, Lbs./ Hour.	Benzine, Lbs./ B.H.P. Hour.	Petrol, Lbs./ Hour.	Petrol, Lbs./ B.H.P. Hour.	Brake Thermal Efficiency. Per Cent.	Analysis of Exhaust by Volume. CO_2.	O_2.	CO.	Temperature of Mixture. ° Fahr.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			Per Cent.											
Petrol . .	3250	24·8	100	..	..	..	..	19·7	0·795	16·15	11·4	0·8	4·2	..
Benzine-Gas	3083	21·5	86·7	353	16·42	2·106	0·0982	..	..	26·0	12·0	0·5	0·7	65
Benzol-Gas .	2895	18·57	75	332	17·9	0·964 Benzol	0·0519	..	..	26·5	13·5	1·3	0·4	70
Gas . . .	2846	17·9	72·3	488	27·21	..	..	..	..	19·35	11·3	0·40	2·3	..
NON-SUPERCHARGING.														
Petrol . .	2313	11·2	100	..	..	..	..	6·36	0·568	22·6	13·0	0·3	1·0	..
Benzine-Gas	2103	8·95	80	168·8	18·88	0·743	0·083	..	..	23·9	12·8	0·3	*nil*	65
Benzol-Gas .	1897	7·65	68·4	171·6	22·42	0·498	0·0652	..	..	21·1	12·2	1·9	0·15	42·1 (No electric heater)
Gas . . .	1916	7·4	66·1	199·5	27·0	..	..	..	..	19·6	12·7	1·05	0·25	..

Weight of benzine added to gas (according to Central Laboratory analyses) = 0·00597 lb. per c.ft. of original gas.

assumed that a four or five stage machine, with intercooling between stages and after-cooling in the case of the final stage, would be employed.

Costs of Compressing by Steam Power and Electricity.

As a typical example of a gas compressing installation, the Author has set out in Table V. the capital charges, maintenance, and running costs associated with a gas compressor capable of dealing with 350 c.ft. of free gas per minute and of delivering at a pressure of 200 atmospheres. Alternative figures are given for steam and electrical driving, the cost of steam being taken as 18 pence per 1000 lbs. and electricity at ·6d pence per unit.

In this example, a five-stage compressor has been allowed for, and the cost of a duplicate stand-by machine with power unit is included in the capital charges. It is also assumed that the machine is run at full load for 10 hours per day and 350 days per year, during which period it would deal with approximately 73½ million c.ft. of free gas.

A gas compressing installation of this size would be capable of maintaining the fuel supply for 25 to 30 passenger carrying vehicles.

TABLE V.—*Showing the Costs of Compressing Town's Gas to 200 Atmospheres.*

With Electrically-Driven Compressors.	£	With Steam Driven Compressors.	£
Capital Charges—		*Capital Charges—*	
Cost of two direct-coupled compressors, each having a capacity of 350 c.ft. per min. free gas, to a final pressure of 3000 lbs. per sq. in., complete with suitable 200 H.P. motors	3700	Cost of two direct-coupled steam driven compressors, each having a capacity of 350 c.ft. per min. free gas, to a final pressure of 3000 lbs. per sq. in., complete with 190 H.P. driving engine	4300
Cost of installing and housing in suitable building	500	Cost of installing and housing in suitable building	500
Total	£4200	Total	£4800
Running Costs—		*Running Costs—*	
Interest on capital outlay at 5 per cent. per annum	210	Interest on capital outlay at 5 per cent. per annum	240
Depreciation and maintenance at 10 per cent. per annum on cost of plant	370	Depreciation and maintenance at 10 per cent. per annum on cost of plant	430
Oil, waste stores, and cooling water	50	Oil, waste stores, and cooling water	50
Labour charges	250	Labour charges	250
Power cost, taking 160 units/hr. for 3500 hrs./year at 0·6 pence per unit	1400	Steam costs, taking 3420 lbs. steam/hr. for 3500 hrs./year at 1s. 6d. per 1000 lbs.	900
Total annual running costs	£2280	Total annual running costs	£1870
Total quantity of gas compressed per annum = 73,500,000 c.ft.			
Cost per 1000 c.ft. compressed = 7·45 pence		Cost per 1000 c.ft. compressed = 6·11 pence	

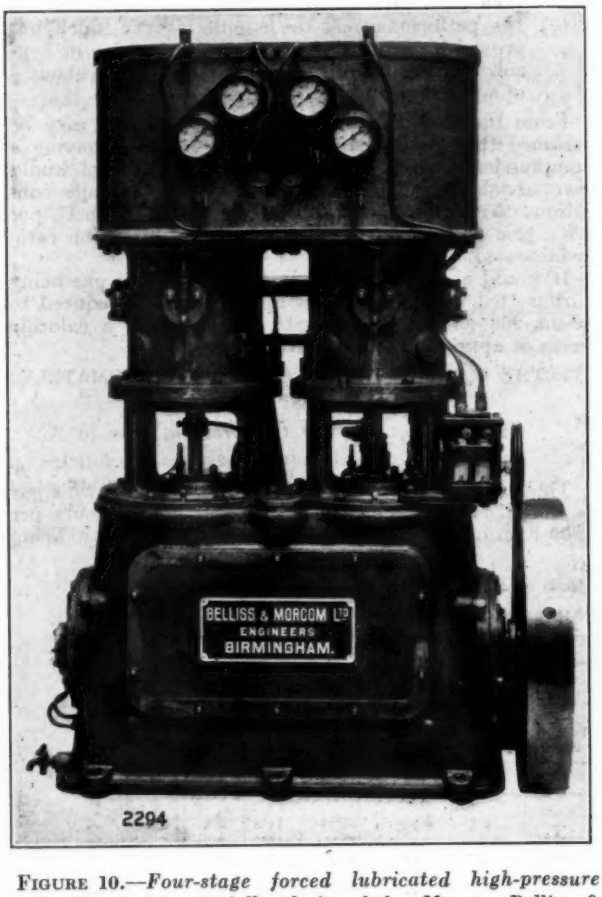


FIGURE 10.—*Four-stage forced lubricated high-pressure gas compressor specially designed by Messrs. Belliss & Morcom, Limited, for the Corporation of Birmingham Gas Department, to deliver gas at 5000 lbs. per square inch.*

VII. COMPARATIVE COSTS OF COMPRESSED GAS AND PETROL FOR THE RUNNING OF COMMERCIAL VEHICLES.

The comparative costs of 475 B.Th.U. Town's gas compressed to 200 atmospheres, and Petrol, are set out in Table VI. below, the figures being based on the assumption that 265 c.ft. of 475 B.Th.U. gas is equivalent to 1 gallon of Petrol.

TABLE VI.—*Showing the Comparative Costs of 475 B.Th.U. Town's Gas Compressed to 200 Atmospheres, and Petrol.*

Price of 475 B.Th.U. Gas at Inlet of Compressor in Pence per Therm.	Cost of Gas Compressed to 200 Atmospheres, in Pence per 1000 C.Ft.		Equivalent Cost of Petrol in Pence per Gallon.	
	(*a*) Compressed by Electricity at 0·6d. per Unit.	(*b*) Compressed by Steam Driven Compressors with Steam at 1s. 6d. per 1000 Lbs.	(*a*)	(*b*)
1	2	3	4	5
3·0	21·7	20·3	5·75	5·38
4·0	26·4	25·1	7·00	6·65
5·0	31·2	29·8	8·27	7·90
6·0	35·9	34·6	9·52	9·17
7·0	40·7	39·3	10·80	10·41

Experimental Compressor for Compressing to 5000 lbs. per sq. in.

A small Compressor, which has been designed and built for the Birmingham Gas Department by Belliss & Morcom, Ltd., Birmingham, is shown in Figure 10.

This Compressor is designed to deliver gas at a pressure of 5000 lbs. per sq. in. when running at a speed of 500 r.p.m. The gas is compressed in four stages with intercooling between each stage of compression, and a final stage aftercooling coil which ensures satisfactory cooling of the gas before entering the Receivers.

All motion parts are forced lubricated by means of a gear pump operated from the end of the crankshaft and enclosed in an oil-tight crankcasing.

Figure 10 shows a 2 crank design, with 3 compression stages on each line, *i.e.*:—

1st, 2nd, and 3rd compression stages on one line, and
1st, 2nd, and 4th compression stages on the other line.

The two first stages discharge into the respective second stages and the two second stages discharge into the common receiver coil for the third stage; thence from the third to the fourth stage.

The High Pressure cylinder and the cooling coils are

surrounded with water and enclosed in an open top tank casing; this arrangement lends itself to ready detection of any gas leakages that may occur at the joints of the unions and other connections.

Arrangements are made to prevent any gas leaking to the atmosphere, or to crankchamber past the piston rings, or the relief valves, by means of pipes which can be connected to the suction pipe line or otherwise.

There is a common gas inlet to both first stages and a suitable filter is fitted in the pipe line to prevent grit or other foreign matter entering the cylinders, a very necessary feature for these high pressure compressors.

All valves are readily accessible for examination without the necessity of breaking any high pressure joints. Relief valves are fitted to each stage of compression and for the final pressure.

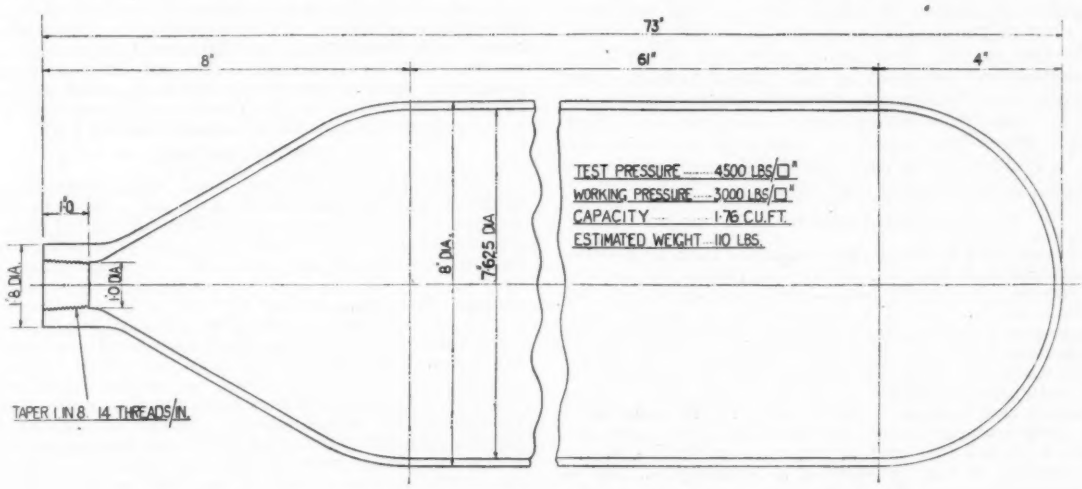


FIGURE 11.—*Showing Section of Thin-walled Steel High Pressure Gas Cylinder.*

VIII. STORAGE BOTTLES.

In regard to the storage of Town's gas on vehicles at pressures of approximately 3000 lbs. per sq. in., it has already been mentioned that in order to reduce the weight to a minimum, steel bottles made of special high tensile steel have to be employed, otherwise the dead weight of the storage system would be so considerable as to render the use of gas uneconomic.

In the case of the vehicles which are being operated on Town's gas in Paris, the storage bottles are composed of heat-treated nickel-chrome steels, and the dimensions approximate to 8 in. diameter by 72 in., with a wall thickness of about ·22 in. The internal volume approximates to 1·72 c.ft.; thus, at a working pressure of 200 atmospheres, the volume of free gas contained in each bottle is about 340 c.ft. The number of bottles carried varies from four to eight, according to the type and weight of vehicle, and the complete gas equipment includes the necessary pressure reducing valve to reduce the pressure of the gas at the engine inlet to atmosphere.

For some considerable time, Vickers-Armstrongs, Ltd., of Newcastle-on-Tyne, have been manufacturing high tensile alloy steel bottles composed of Nickel-Chrome-Molybdenum steels, which, after being suitably heat-treated, are eminently suitable for the storage of gas at these high pressures. The Author understands that high tensile steel bottles suitable for the storage of gases at these high pressures can be supplied also by the Chesterfield Tube Company, Ltd., Chesterfield.

With the employment of light steel bottles such as have been referred to above, it will be understood that the characteristics of the steel used for their production should be such as to ensure:

(1) A reasonable factor of safety.
(2) That in the case of rupture, the bottle will not disintegrate or fragment.
(3) Homogeneity and even wall thickness.

From the above, it will be apparent that extreme care must be exercised in the manufacture and heat-treatment of high tensile bottles of this type, and also that there should be a complete knowledge of the elastic properties of the steel. In the case of the bottles manufactured by Messrs. Vickers-Armstrongs, Ltd., the material employed is known as " Vibrac " steel, which contains approximately 2·5 per cent. Nickel, ·52 per cent. Chromium, and ·58 per cent. Molybdenum, with a carbon content of about ·33 per cent.

As before mentioned, the elastic properties of this steel, when suitably heat-treated, are such as to ensure a reasonable factor of safety, and a high resilience. Figure 11 shows a section of thin-walled steel bottle of " Vibrac " steel, which has a water capacity of 1·76 c.ft. and a wall thickness from ·19 to ·22 in.

At a test pressure of 4500 lbs. per sq. in., which represents a 50 per cent. increase above the working pressure, the direct stress in the walls is approximately 40 tons per sq. in ., which is approximately 6 tons per sq. in. below the true elastic limit of the material.

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Repairs, Maintenance, and Construction of Industrial Heating Apparatus . . . . F. L. Atkin.
Gas Journal—20th May, 1931.

Economies to be derived from the Use of Gas Industrially . . . . . C. M. Walter.
Gas Journal—25th November, 1931.

Further physical properties of this material are given below.

Yield point, in tons per square inch	59·5
Breaking stress, in tons per square inch	67·9
Elongation, per cent.	22·8
Reduction of area, per cent.	59·1
Bending test, angle turned through	180° (not cracked)
Izod, foot pounds.	53·5

It would be well to mention, at this point, that the Regulations which at the present time apply to the transport and storage of gases in steel bottles at these high pressures do not cover the requirements demanded by this special application of Town's gas at high pressure, but in view of the special consideration which has been given to this matter, it is anticipated that at an early date sanction will be given by the proper authority for high-tensile steel bottles of approved design to be employed in connection with passenger-carrying and other vehicles. When this necessary authority has been obtained, it is intended to continue the experimental work on vehicles under running conditions.

DISCUSSION.

The PRESIDENT: I wish to give as much time as possible to the discussion of this very interesting paper, but I must, before opening the discussion, express the thanks of the Institution to Dr. Walter for presenting to us the very important paper on a subject which is of paramount interest at the present time. As Engineer-in-Charge of the Industrial Gas Laboratories of the Corporation of Birmingham, nobody was better qualified to speak on this subject than Dr. Walter; and I am sure we are very much indebted to him for preparing such a full and extensive paper upon this subject. I should like also to express our thanks to the Gas Committee of the Corporation of Birmingham and to their General Manager, Mr. A. W. Smith, for having kindly permitted Dr. Walter to publish the information contained in this paper.

Mr. STEPHEN LACEY (Gas Light and Coke Company): I am very glad to have an opportunity of taking part in this discussion. The Birmingham Gas Department, as we all know, have led, and are still leading, the way in the practical application of town gas for the kind of work illustrated in this paper, and we are all greatly indebted to Dr. Walter for putting at our disposal the fruits of his experience and for defining the theoretical considerations which underlie the design of gas furnaces. I am not sure that everyone will follow the higher mathematics given in one part of the paper, but in any case I think we can take that for granted and obtain a great deal of valuable information from figs. 1, 2, 3, and 4, which I think together give the gist of the matter in an easily digestible form. The difficulty of finding a completely satisfactory definition of furnace efficiency is well illustrated by the thermal balances which Dr. Walter gives for the carburizing furnace, because when the charge has been soaked, which appears to take about 5 hours, the temperature has to be maintained for a further period in order to complete the carburizing process. During this latter period useful work has presumably been done, but as no heat has been added to the charge the furnace efficiency quoted is inapplicable.

POSSIBILITIES EVERYWHERE.

There is just a little danger, I think, of an engineer of an undertaking, with no large factories in his district, looking through the paper and saying to himself "There are no opportunities of this sort in my district," and, therefore, taking no further action. The truth is, however, that nearly every factory has some heat process work and what Dr. Walter calls the economical value of gas in competition with other fuels when applied to a particular process is higher when the process is on a moderately small scale. In the area of supply of my Company there are some 17,000 factories, large and small, and gas is used for a very great variety of purposes, and it is increasing every year. From the competition point of view, however, we are on the firmest ground with regard to medium sized industrial gas appliances. With the very large units we are up against severe competition with oil, and with the very small units we are faced with competition from electricity, but of course there is no secure market for industrial gas with inefficient apparatus. That is a lesson we are learning every day. It is far better to hold the lead by increasing efficiency than by reducing the price of gas. The latter, I suggest, should be the last resort. Perhaps I may be allowed to give an example from my Company's experience. One of our industrial consumers was persuaded to use electricity at a low price per unit in place of gas, although until then he was quite satisfied with his gas installation which, by the way, we had not been allowed to modernize. A modern electric furnace was installed on trial, and after a short period of running it was found that, whereas the cost of doing certain work by the gas furnace was 7½d., the same work could be done by the electric furnace for 5¼d. We were then given an opportunity of improving on the old gas figures, and eventually a modern gas furnace was installed which did the same work for 2½d. That no doubt is an extreme case, but it is nevertheless valuable as an example of what can be done by increasing the thermal efficiencies of gas furnaces. The manufacturers of industrial gas appliances have made great improvements in the larger furnaces during the last 10 years, but there has not, I think, been the same improvement in the smaller units. With the object of making good that efficiency, a series of small furnaces has lately been designed for mass production at our industrial workshops, which compare very favourably, we think, with the old-fashioned furnaces that are still on the market, with regard to initial cost, efficiency, and also appearance. Appearance I may say is of much greater importance than is generally recognized, because up-to-date factory managers like to have smart looking tools.

CENTRAL HEATING.

I would like to say one word with reference to Dr. Walter's note on central heating by gas. We are all aware, I think, of the enormous possibilities of central heating by gas provided gas can be sold at a price that will obtain the business in competition with oil—*i.e.*, large-scale central heating. Dr. Walter mentions an economic price of 4d. per therm. That may be true on very large installations, but I suggest that the economic price is substantially higher in some parts of the country and also in special circumstances. We are getting quite a substantial amount of central heating by gas at prices very much higher than that, and I do think that the Gas Industry must not lose sight of the fact that coke is also in the picture. In the last 10 years the oil people, very energetic and enterprising, have made oil burning as nearly as possible like gas burning. They have thermostatic control and so on, and, in fact, they apply thermostatic control more generally than we have done up to the present with gas. Therefore, I suggest that the possibility of using thermostatic control for coke boilers, controlled air supply, &c., should be considered; we certainly have to consider coke and gas together for central heating; we must not altogether neglect coke.

COMPRESSED GAS AS A MOTOR FUEL.

Coming to the second part of this interesting paper, I might perhaps mention that a Joint Committee representing the Birmingham Gas Department, the Tottenham and District Gas Company, and my own Company (the Gas Light and Coke Company) was formed some months ago with the object of looking into the whole question of the use of compressed gas as a motor fuel, so that by pooling information and dividing up the investigations as far as possible, the outstanding problems might be solved more quickly. Dr. Walter is, of course, a member of that Committee, and most of the data which he has put before you to-day have already been made known to its members. I should like also to say that we have all been very greatly impressed with the work that Dr. Walter has done in this connection, and to say how very grateful we are to him for the way in which he has set out his results. Also I am equally certain that Dr. Walter will be the first to admit that a very great deal of work still requires to be done. As far as we can see at present there appears to be a field for gas as a motor fuel where gas can be supplied at a really low rate and where the re-charging of the cylinders on a vehicle more than once a day presents no insuperable difficulty. In the present stage of development perhaps the particular problem before us is to enable the vehicle to carry an amount of gas equivalent to its normal petrol capacity without unduly exceeding permitted axle weights. Dr. Walter has given the estimated cost of operation up to 3000 lbs. per sq. in. In practice, however, it would not as a rule be possible to fill the vehicle cylinders direct from a compressor, and to ensure economic work it would be necessary to have storage cylinders with gas compressed up to, say, 5000 lbs. per sq. in. from which the vehicle cylinders would be charged as required. When considering the total cost, therefore, it is necessary to take into account this higher compression and also the capital cost of storage and, of course, the vehicle cylinder and other equipment. I might, perhaps, add that the Gas Light and Coke Company is working in close co-operation with the London General Omnibus Company in this matter. That Company is now carrying out a series of tests and is going very carefully with us into the whole question of cost. Once more I would say that I am very much indebted personally to Dr. Walter for an extremely interesting paper.

EXPERIENCE AT TOTTENHAM.

Mr. H. C. SMITH (Tottenham): I should like to add my thanks to those of Mr. Lacey to Dr. Walter for his very interesting paper to-day. Although I appreciate to the full all that Dr. Walter has to say in the earlier parts of

his paper, it is really with regard to the latter part of the paper that I should like to say a few words—*i.e.*, with regard to the question of running vehicles on compressed gas. Mr. Lacey has referred to the Joint Committee which was formed, of which I am a member and on which we pool our information. We felt at Tottenham that instead of going to any outside body to co-operate with us in doing the tests, we could not on this occasion be like the doctor and try it out on the dog; we must try it out on ourselves. So we fitted up a lorry with the gas cylinders that Dr. Walter has described in his paper, and that lorry for the last four or five weeks has been running on compressed gas. There are six cylinders on this lorry, each of which has a capacity of 1·75 c.ft. At the moment we are compressing to 2000 lbs. per sq. in., but we are doing this with a compressor which we have hired from the British Oxygen Company, as that happened to be the only size compressor which they had available at the time, but it is our intention at a later date, if the experiments warrant it, to put down a larger compressor for compressing to, say, 4500 or 5000 lbs. per sq. in. into a receiver from which the lorries can be charged at a rapid rate—say, five to ten minutes. These bottles of compressed gas at 3000 lbs. pressure will contain the equivalent of 350 c.ft. of gas, or a total of 2100 c.ft. of free gas. For the lorry in our case 250 c.ft. of gas will be the equivalent of one gallon of petrol so that we have practically the equivalent of 8 gallons on the lorry in these six cylinders, and that will be sufficient for a normal day's work of this particular lorry. Taking the annual consumption of that one lorry it will be the equivalent of approximately 25 slot consumers. I quite agree with Dr. Walter's conclusions, so far as we have been able to judge them. We have a lorry working on the road, and we are finding out various differences between running an engine on petrol and running on gas under actual road conditions, whereas Dr. Walter has done his work under test bench conditions, but the figures which he gives in his paper will be invaluable.

Advantages of Coal Gas.

We certainly have found that the maximum power is lower with gas than with petrol, as one would imagine, but at the same time the power of the engine is quite sufficient for the lorry to do its job on gas. Of course, the CO content is very much reduced in the exhaust gases when using coal gas. We also found that there is better acceleration and, of course, if any of you have tried to start a motor-car engine running on gas you know it is very much easier to start than it is to start a petrol engine. I am sure Dr. Walter has found that to be the case. With regard to cylinders, I do think we ought to stress the very remarkable properties of the cylinders, which really make possible the running of motor vehicles on compressed gas. I was privileged to witness the tests on the cylinders, the particulars of which Dr. Walter gives you, and from memory I should say the figures he gives of the yield point of 59·5 tons and a working stress of 67·9 tons are minimum figures. Certainly the maximum breaking stress that I saw went up to 71 tons. Another very remarkable test that was made was that of pumping oil into the cylinders at a pressure of 4500 lbs. per sq. in. when the total expansion on the cylinders amounted to 16·9 cub. m. Then the pressure on the cylinders was released, and they went back to their original state, there being no permanent set. Dr. Walter refers to the fact that the regulations at present applying to the transport and storage of gases in steel bottles would prevent compressed gas being used on passenger carrying and other vehicles. While I agree with the regulations preventing the carrying and storage of gas at these pressures on passenger carrying vehicles, we did find that the Government Departments which were concerned were quite agreeable to our experimenting with gas at these pressures on our own vehicles. In fact, they were very sympathetic and did everything they possibly could to help us. I had a word with Dr. Walter with regard to our lorry, and I have suggested that I would try and get the lorry, which is actually running on gas, brought along to the hotel so that he could show it to any members who wished to see it. I hope that between 4.30 and 4.45 this afternoon the lorry will be in the garage at this hotel. I am sure Dr. Walter will be very pleased to show it to any members who may be interested. I think the most interesting feature at the present time is that the lorry can be fitted up in such a way that the man in the street would not realize there was anything unusual about the lorry. As far as he was concerned, the lorry might be running on petrol.

Higher Efficiencies Needed.

Col. W. M. Carr (Stretford): The paper which Dr. Walter has given us is in itself an indication of the vast field which is open to us as an industry. In dealing with practical applications he cites some seven headings, each of which in itself is a subject which we might discourse for a whole afternoon with advantage. The undertaking of which he controls the Industrial Research Department has shown, and indeed is showing, with some other large undertakings, a lead in the matter of indicating at any rate the work that has to be done; but while Dr. Walter has cited certain figures, in my small incursions into the field of industrial heating I have become very timorous of citing figures as indicative of results which can be achieved in industrial heating. My first real experience was in connection with the melting of lead, which, of course, is quite an easy proposition from the gas point of view. In that particular instance the business was lost because the cost of gas worked out at no less than 5s. 3d. per ton of lead melted, with the result that the manufacturer reverted to the use of solid fuel which he got down to a cost of 2s. per ton of lead melted. That was heating lead in pots which contained 3 tons of lead and gave an output of 600 lbs. of lead every 20 minutes. A proposition was then put forward for gaseous heating, but this time in a container which was to hold rather under a ton of lead with a normal working capacity of ¾ cwt., and, of course, designed to avoid the admission of secondary air on combustion of the gas; actually the whole of the air in the combustion chamber heating the vessel being admitted with the gas. In this way a figure of 1s. 3d. per ton of lead melted was achieved, as against 2s. per ton with solid fuel and the previous figure of 5s. 3d. for gas, the lower figure being achieved with the same thermal cost for gas. I only cite that as an illustration which Dr. Walter's paper bears out and which he himself has repeatedly stated—namely, that it is in the efficiency of application that we have largely to look for our results. It is true that when we pass from the soft metals to non-ferrous metals, and get on to steel heating, the question of price becomes a factor, but to those of us who are manufacturing gas in the vicinity of the coalfields and who are able to put gas into the holders at 1s. per 1000 c.ft., and under, that field is open and awaiting our assault.

Question of Heat Transfer.

One other point I should like to refer to, although it is not specifically dealt with by Dr. Walter, and that is the question of the sizes of container. Recently, in association with Dr. Walter, we have had some conflicting results, particularly in the melting of brass, in which we have been able to obtain a higher efficiency with a smaller crucible, one containing 70 lbs., as against a crucible containing 150 lbs., and it would be useful if Dr. Walter would be good enough to express his opinion on that particular aspect of heat transfer. It arises rather on the point that he raises with regard to potential heat transfer, and it does appear that in connection with the potential heat transfer the size of containers, particularly in metal melting, is an important factor.

If one might be permitted to generalize for a moment on the second part of the paper, it appears to me that we in the Gas Industry have in our hands the solution to a great extent of our industrial troubles. The politicians told us that in cheap electricity lay the solution of the nation's trouble so far as heating and power were concerned, but we must, from our very experience, believe that the solution really lies in making available in the cheapest possible form the natural wealth of this nation, which is coal; and it appears that this lies in carbonization. We have lost a great deal of the utilization of that natural wealth due to the development of the internal combustion engine and the substitution of petrol for coal on the roads. Then came the Diesel engine, and now there is the suggestion that the Diesel engine or the Diesel electric locomotive shall replace the coal fired locomotive on our railways. It is in these circumstances that I suggest as a matter of interest to the Institution that we in the Gas Industry must be alive to that development. The representative of a large firm of electrical engineers who has been, in a measure, interested in the development of the Diesel electric locomotive, said to me the other day, apropos of what has been done in the use of gas in road vehicles and which is so fully described in this paper, "What is the Gas Industry doing, and has the Gas Industry considered the possibility of the application of gas for driving an electric locomotive of a similar design to that of the Diesel electric locomotive?" It appears that the question of the weight of the container is not of such vital importance in connection with railways as it is on a road vehicle. Another point in that connection, speaking in general terms, is that the railways themselves quite naturally are disinclined to go to a foreign product in place of a home produced product, which incidentally also forms a considerable part of their goods traffic. Thus, if we can give them an equipment in gas, which will give the same results as the Diesel electric locomotive, by means of a gas engine driven on the lines of the Diesel locomotive, then we shall be doing a great service to the nation, and it is a line of research which appears to follow directly upon the line of research which has been followed by Birmingham, Tot-

tenham, and the Gas Light and Coke Company in connection with the running of road vehicles.

Economic Value of Gas in Competition.

Mr. C. A. Masterman: Dr. Walter is to be congratulated on dealing with a subject of which too little has been heard in the meetings of the Institution of Gas Engineers. Gas in industry is of a special importance at the present time when industry is at a low ebb, and factory managers should be overhauling their plant and costs in order to take full advantage of the opportunities which will come with the recovery of industrial activity. The fact that Dr. Walter has found room for mention of part only of the industrial applications of gas is an indication of the widespread opportunities which are available. I would suggest that in confining himself to compressed gas as the possible future development, Dr. Walter is quite unnecessarily limiting the scope of future possibilities, which I conceive of as embracing a number of other perhaps more easily developed activities. The inference, for instance, that central heating by gas is essentially linked up with a boiler is surely imposing a quite unreal limitation upon the methods of application of gas for this purpose.

The author discusses the economic value of gas and other fuels and infers that a gas cost of 4d. per therm is a prior condition to the satisfactory adoption of gas as an industrial fuel. Here he is undoubtedly pessimistic, since, however much we on the utilization side of the Industry would like to advocate gas at such a rate, it remains possible to demonstrate an economic proposition at a figure twice as high. At 4d. per therm the possibilities would be immensely increased provided the other fuels were not reduced in like proportion. Comparisons of costs as between different fuels require cautious handling, since the competing appliances can only be compared fairly if both are in the same degree of development. Figures are all too familiar purporting to give comparative costs but actually showing costs on a modern appliance using the fuel advocated against the costs of an entirely obsolete appliance using the rival fuels. Naturally, the resulting figures prove exactly what is required without anyone really being any the wiser. Dr. Walter's paper puts on record certain facts and figures relating to the industrial applications of gas which, while they may be valid now, will we hope be obsolete in a few years' time in consequence of his own efforts at Birmingham and the efforts in general throughout the Gas Industry. The fact that there still remains room for technical improvement in the application of gas means that we may look forward to being in an increasingly strong position as these improvements are effected. Dr. Walter in referring to the use of compressed gas for motor vehicles gives some interesting results obtained with a 5 : 1 compression ratio, and himself refers to the undoubted advantage which will follow a higher ratio. Can he estimate costs on the basis of, say, 8 : 1 ratio such as would surely be adopted in the event of gas fuel becoming popular for this purpose. The author's reference to the results with two types of mixing device does not state whether the carbon monoxide in the exhaust gases vary in the two cases, the contrast between which is somewhat puzzling.

Finally, in congratulating Dr. Walter on this interesting paper, reviewing the present and anticipating the future there is one word to be added. We are most of us familiar with the ramshackle gas furnace or other appliance obsolete, but still in use, inefficient, uncontrolled, uncertain in performance, and an eye-sore even in that ancient day when it was new. When considering new applications of gas in industry do not let us forget and so accept the presence of these obsolete gas appliances. I am convinced that it is out-of-date gas apparatus which constitutes our most serious damage—and slanderous competition.

Mr. T. P. Ridley (Newcastle-on-Tyne): I should like to add my congratulations to those of previous speakers to Dr. Walter for a most excellent paper in which he sets out very clearly the general principles of combustion as they apply to coal gas. He sets out practical applications and gives tables of consumption and the economic values of fuel, which I am sure will be of the greatest value at the present time at any rate to industrial salesmen. Birmingham has been in the forefront, as has been mentioned, and I think Birmingham is to be congratulated on having Dr. Walter, while the Gas Industry is to be congratulated in having a Birmingham, because Birmingham has always been ready on every occasion to give every help and all the knowledge they have collected by their various experiments in connection with this and other subjects. I should like publicly to pay a tribute to Mr. Smith and Dr. Walter for the help we in Newcastle have received from them, particularly on the industrial gas side, because we are infants in this matter by comparison.

Facing and Overcoming Competition.

Two or three years ago we found that the consumption of our large industrial consumers began to dwindle, and fall almost to half, the reason being competition from oil and electricity. We thereupon started a campaign in the industrial field, and the result was that we immediately stopped the rot. Indeed, in some factories we now have the whole of their general heat-treatment plants operating by gas. Certainly in these depressed times many of our old industrial users are taking less gas, but we have found new uses for gas and taking advantage of being on the coalfield and having large supplies of coke oven gas, we have been able to quote prices for business which nothing but low prices would have obtained. In connection with our industrial department we have a demonstration room and have become the centre for the development of industrial gas. Several neighbouring undertakings are subscribing members to this, and I do hope that the other districts will soon get their centres under weigh, so that we can have a co-ordination of the centres where the information which is obtained in the various districts may be pooled. In our district we send out data sheets relating to the various jobs which we come in contact with, and that has been helpful to the other districts. With regard to Plates 6 and 7, this relates to an installation which has a consumption of 20 million c.ft. per annum, and I understand it is the largest bread baking installation in the country, and it certainly turns out a superior article. We do not want to claim the whole of the benefit, but there has been a very marked increase in the sales of that bread since the bakery turned over to gas; and the result is that at the present time we are negotiating with another bakery of equal size and which would have an equal consumption.

A Huge Potential Load.

I think Dr. Walter has done a real service to the country in bringing before us to-day the results of his experiments and researches in the design of the carburetting of gas for motor vehicles using high-speed internal combustion engines. We ourselves hope to make an early start with experiments in the same direction in conjunction with our bus company. Col. Carr has referred to the great possibilities of the industrial development of gas and what it may mean to the nation; and in this particular case I may say that I have estimated that the bus stations in our area consume some 5 million gallons of petrol per annum, which would be equivalent approximately to 1000 million c.ft. of gas. Multiply that all over the country and consider the effect upon the coal mining industry, the railways, and the many firms supplying stores to those industries, and we get an astounding picture. It cannot all be done with a stroke of the pen; we must go slowly and consolidate our position as we go along. Do not let us go rushing headlong into this business and then find out that we have made mistakes. I believe Birmingham is on the right lines in going quietly on with these experiments, and I am sure they have done a great service to the Industry in making the results known to us to-day.

In regard to the general question of supplying industrial gas there are two main difficulties. One is the provision of staff and the other is the question of the price at which gas must be sold. With regard to staff, I am sure Dr. Walter will agree with me that it is very difficult to find really suitable men, because the men we want are those with a knowledge of the local industries from the inside. As regards prices a great deal has been said this afternoon, and while we have to impress upon the prospective customer that it is not a question of the thermal price, but the final price, I nevertheless maintain that we have, as an Industry, to consider lower prices than we have been accustomed to in the past. I have taken out figures with regard to my own Company for various classes of consumers—I do not think we are any exception in this respect—and these show very emphatically that the industrial group of consumers as a body are paying too high a price, and that they are carrying the burden of other consumers who are uneconomical. We cannot change all this at once; we have to go gradually and take it step by step. I think also that some of us will have to revise our views somewhat with regard to the question of special prices for special purposes in order to get loads which are economically ours. I would again like to thank Dr. Walter for his paper and in conclusion say that there are enormous fields for development, but there is, in some quarters, apathy. Let us cast this apathy aside and let us go forward with enthusiasm, and let us be grateful that we live in such interesting times. Notwithstanding the severe trade depression in our district and the weather conditions unfavourable to gas consumption in 1931, we maintained our total sales, which we would not have done but for our activities in the industrial field.

Development of Mixing Devices.

Dr. J. G. Stewart: I am always interested in Dr. Walter's work, and I know a good deal about it. To-day, however, I should like to make a few remarks about the gas engine, which has interested me for many years. I think the gas engine used on motor vehicles will come, and to-day I just

want to say that I think the efficiencies obtainable should be very much higher than Dr. Walter mentions. The gas engine should not lose its efficiency with drop of speed, but Dr. Walter actually shows a consumption of gas at 1500 r.p.m. which is about half that at 500 r.p.m. There is an indication there, I think, of bad mixing. This mixing is a thing which will probably take some developing because actually to secure the proper proportion of gas and air is not at all a simple matter. When once that is solved, however, the efficiency of the gas engine should be very much higher than it is now; I mean the high-speed gas engine. You can actually see that from the curves in the paper. The gas taken per revolution at full throttle—and I suppose the tests were intended to be done at full throttle—should be the same per revolution whatever the speed, but actually from the curve you will see that the gas taken is 0·0067 c.ft. at 1000 revolutions, and it increases to 0·01 c.ft. at 1900 r.p.m. In any internal combustion engine you usually expect a different result. The petrol engine, for instance, loses its charge as the speed goes up. Any racing engine must have large valves and large passages for the air to get in, so that there is an indication in the present case of bad mixing. We also found that that has a bearing on the torque of the engine, which in the author's case increases from 1000 r.p.m., and is very much larger when you go up to higher speeds. The petrol engine, as you know, has about its best torque at medium speed, while the maximum speed that the petrol engine makers give you any figures for, indicates a smaller torque. From these considerations I feel quite sure that Dr. Walter will not be long in producing very much better figures, and I wish him luck in all his future experiments.

Mr. W. B. McLusky (Halifax): It had been my intention to put before you to-day some figures showing the success we have had in Halifax in competition with what we call the alternatives to coal gas, but as time is short I will not give you these figures now, but I will send them in for the Proceedings. Like other speakers, I thank Dr. Walter for coming here to-day, because he has pointed out to us work that is necessary if we are to develop the industrial load. There was a time, as many of you will remember, when the industrial load made headway almost by its own momentum, and we were able in those days to get our own price. Now, however, we are faced with very keen competition, and we have to ask ourselves two questions—namely, Are we going to say that *that* is the price, and that there is no other price, and let the business go if necessary; or are we going to sell our gas at competitive prices and retain our business?

An Interesting Comparison.

There was a time when the industrial section of the business was the most important, but to-day the industrial centres in the matter of gas consumption are lagging behind the residential centres. I have taken out a few figures in this connection and they may surprise you a little. For instance, it is a remarkable think that the consumption of gas in this country for all consumers is only 3 c.ft. per hour per consumer. That is all that Great Britain is doing to-day and it includes industrial and domestic consumers. Again, throughout the whole country there are only 29 undertakings whose customers use on the average more than 3000 c.ft. per month. There are only 25 undertakings whose customers use an average of over 3000 c.ft., and under 4000 c.ft. per month and there are only 5 undertakings whose customers use an average of over 4000 c.ft. per month, and none of these, strangely enough, is an industrial area. Of these five, Bath has an average of 54,270 c.ft. per annum, Goring 54,040 c.ft. per annum, and Helensburgh has an average of 53,640 c.ft. per annum. Coming to the seaside we find Margate has an average of 40,150 c.ft. per annum, while, comparing that with Coventry, an industrial town, the latter has a figure of only 44,900 c.ft. per annum. When we come to Birmingham—and we know what a vast amount of hard work and progress has been made there—we find the figure is only 48,070 c.ft. per annum; at Reading the figure is 48,270; Bournemouth 48,960. And then we come to London, of which we have heard a great deal, and here is the result: In the case of the Gas Light and Coke Company, the figure is only 35,620 c.ft.; for the South Metropolitan Company the figure is 36,640; at Croydon it is 37,510; and at Wandsworth it is 38,110. Down to the coast again we find Eastbourne has a figure of 38,730 and Brighton 38,250, while in the Midlands, at Buxton, the figure is 39,370 and at Leamington 39,400; at Belfast the figure is 40,690 and at Bangor it is 45,000. I am saying all this to myself as well as to you, because I am in an industrial town. In the West Riding of Yorkshire we have not perhaps done so badly, but our average consumption per customer is only 30,000 c.ft. per annum. These little residential towns that I have mentioned can beat us; and if we are going to help the industries of this country I think we ought to do something now to develop an increased use of gas. It is sometimes said that the price of gas is too high, but you know as well as I do that if the price of gas is too high it is mainly because the consumption of gas is too low, and the only way to get the price down is to increase the consumption, which you will never do if you keep up the price. [Loud laughter.]

Coke Oven Gas at Rotherham.

Mr. J. T. Haynes (Rotherham): First of all may I add my congratulations to Dr. Walter for his excellent paper, which is in keeping with his character as a practical scientist far removed from the abstract dreamer. I also wish to express my appreciation of the generous assistance he gives to individual members of our profession as well as for his work on behalf of the Industry as a whole. I would particularly like to refer to the fact that Dr. Walter has taken me into his confidence in his experiments on gas for 'buses. It is only about twelve months ago that I entered the field of industrial gas, and with such a short experience one hesitates to take part in this discussion, but it might be of interest if I add some observations on our experiences in Rotherham. The conditions of the area are perhaps unique, but the experience may prove useful to others.

Dr. Walter has pointed out in his paper that gas has made headway in the industrial field largely owing to the high efficiencies which are obtainable with properly designed gas furnaces compared with coal furnaces (low efficiency). But lagging, recuperation, and properly proportioned combustion chambers are not peculiar to gas-fired furnaces, and we are confronted with the fact that when we have arrived at an equivalent value of gas for a particular purpose the consumer can reconstruct his old furnace, and by doubling his existing low efficiency at once cuts in half our value of gas. At the present time I am in competition with a coal-fired continuous billet heating furnace fitted with mechanical stoker and of a capacity of 5 tons per hour. For a period of some months it has been using only 1½ cwts. of coal per ton steel and claiming—I say claiming—an efficiency of 70 per cent. In this case the equivalent value of gas as a fuel is only 0·7d. per therm. Dr. Walter has already pointed out that coal can be delivered at the furnace for 0·5d. per therm. This is not a fairy tale, it is a highly interesting war against smoke and dirt and waste of coke oven gas. From several quarters there has been not very helpful criticism of the publicity given to Rotherham's willingness to cater for the demand for a cheap gaseous fuel, but our experience in Rotherham has convinced me that it would be futile for the Rotherham Gas Department to offer to the heavy steel trade the usual schedule of gas prices for large consumptions, magnanimously allowing as much as 20 per cent. discount off standard domestic prices. I can assure you that gas at 1½d. per therm has not been offered in any spirit of bravado.

On Competitive Prices.

Under the guidance of Dr. Walter we investigate the purposes for which gas is to be used, and in each case determine the equivalent value of gas as compared with solid fuels. We then endeavour to offer gas to the prospective consumer at a price which he cannot refuse. A small margin of profit is required, but as a municipal undertaking we believe that if we can help the local manufacturers to reduce their costs and at the same time turn out a better article, then the town will benefit by an improvement in trade. How far company undertakings can move on similar lines must be determined by the more venturesome for themselves. To carry out the investigations we have enlisted the services of the Rotherham Technical College—an institution well equipped and which has a staff capable of developing an industrial laboratory. Here again we have the guidance and assistance of Dr. Walter and in addition encouragement from the Board of Education. Needless to say, this collaboration is much less costly than the setting up of the proposed central area Industrial Gas Laboratories, and may I add that any information we obtain is at the service of a central clearing house if the Gas Industry cares to make use of it. There is one other argument which we have had to face, and unfortunately the recent floods have put one or two in the position of being able to say "I told you so." The industrial user of gas is entirely dependent on one source of supply. When using coal he can draw from several collieries, and the oil industry is so organized that a failure at one point can be made up quickly from another. The record of the Gas Industry for continuity of supply is a proud one, and I am glad to say that as far as the statutory domestic supply is concerned Rotherham has kept the flag flying, but I regret that in the circumstances at the time it was impossible to maintain the supply for industrial furnaces. This seriously affected only two or three works as others had troubles of their own much more serious than a temporary shortage of gas. The problems which we have to face in Rotherham seem—to us—to be of considerable magnitude, but we are not in

any way pessimistic. On the contrary; during the year 1931 the gas consumed by industry in Rotherham increased by nearly 25 per cent. and was 48 per cent. of our total output. The total gas sold increased by 10 per cent., and the indications are that the rate of increase will be maintained during the current year. But I am definitely of the opinion that those gas undertakings who continue to nibble at the industrial cheese with only delicate scales of discount will never satisfy their hunger for large industrial loads.

The Author's Reply.

Dr. Walter, replying to the discussion, said: Referring first to Mr. Lacey's remarks, I was very interested to hear some of the figures that he gave us concerning the industrial development in his Company. With regard to the economic value of gas I shall perhaps be answering points raised by other speakers if I deal with this question now. I do want to be clearly understood that when dealing with very large consumers, where we may get competition from either fuel oil or producer gas, that is the type of installation which seems to point to a figure of 4d. per therm. Consumers of this type I should class as taking from 50 million up to perhaps 200 million or 300 million c.ft. per annum. At the same time, I can quite appreciate that in the case of smaller units and firms using only one or two furnace units, gas at a very much higher price would at some time prove economical. I was very interested to have had the opportunity recently of inspecting some of the smaller types of furnace to which Mr. Lacey referred, and I am sure these will eventually prove to be a very useful type. I am pleased to say that we have already samples of them in Birmingham in operation. I am now speaking of the smaller improved type of furnace which Mr. Lacey mentioned in the latter part of his speech. With regard to economic values of gas for central heating, here again the price of 4d. per therm would apply principally to installations having boiler units of over one million B.Th.U. heating capacity, and, of course, with regard to competition from oil the price of gas would depend on the value of oil in the particular district. In installations of this kind the economic value of 4d. would apply to units of one million B.Th.U. and with oil ranging about 72s. per ton. Such units would be automatically controlled and practically all labour would be eliminated. Mr. Lacey referred also to the large amount of work that is being done in the development of the use of gas on motor vehicles. All of us who have been experimenting on these lines with compressed gas appreciate that the more work we do the more we find it necessary to do in order to satisfy ourselves on certain points, but the question of capacity from the point of view of the mileage which a vehicle can run on a single charge is certainly of very great importance, and at the moment that seems to me to be one of the principal difficulties in connection with vehicles which at present only charge with fuel once a day. It does seem possible, however, from the practical point of view that we shall be able to get a circumference of action of something like 60 to 70 miles per charge on a vehicle of moderate weight, and the replacement weight—*i.e.*, the extra weight added including gas, *plus* cylinders, *plus* auxiliary gear—amounts to about 70 lbs. per replaced gallon of petrol. This figure, high though it may appear for a vehicle having a gross weight of possibly 6 or 7 tons, is not so serious as it appears because vehicles of that type do not depend on a high rate of acceleration and so the dead weight does not seriously affect the running of the vehicle. I appreciate Mr. Lacey's point with regard to the cost of storage. In our own installation which we have for experimental purposes it is intended to install storage bottles to store gas at 5000 lbs. per sq. in. pressure for filling the vehicles at 3000 lbs. per sq. in. In the case of a very large installation such as I have referred to in my paper the extra cost of storing during the night period would amount to £4000. I have assumed in an installation of that size that storage for 20 minutes would be allowed for, and should a period arise when no vehicle is ready for charging, the gas will be pumped at an elevated pressure of 5000 lbs. per sq. in. into storage tanks having a capacity of 6000 to 7000 c.ft. However, the cost of that has been allowed for in the capital expenditure and amounts to £150 using carbon steel containers because there would be no necessity to use alloy steel containers for stationary storage tanks.

I was very interested in the remarks of Mr. H. C. Smith particularly in view of the fact that he has such a vehicle running on the road. It is very kind of him to arrange for this vehicle to be here for the inspection of anyone who may be interested, and as time is getting on, and you would probably like to look at the vehicle, I must not occupy too long with my reply. Mr. Smith mentions that he has noticed a difference in power. Of course that is very noticeable in a way, although he also mentions that the acceleration is very smooth. I am afraid in many instances, especially where gas was used during the war from storage in balloons on the tops of vehicles, this loss of power which certainly was there was not noticed because the engines were well above their work, and the smoothness of acceleration rather masked the loss of power. I understand from many users of gas during the war period that they did not notice any loss of power when transferring from petrol to gas, but obviously they must have lost about 20 p.ct. from the peak power output point of view. With regard to easy starting, that has always been a big point in favour of gas for the heavier vehicle, which, on a cold winter's morning, sometimes causes a great deal of trouble in starting up on petrol. As to the cylinders and the expansion of the special steel bottles, it is interesting to know that the expansion before bursting is not less than 14 per cent. of the total volume and the bursting pressure is 10,800 lbs. per sq. in., with a working pressure of 3000 lbs. per sq. in. and a proof pressure of 4500 lbs. per sq. in. I should also like to endorse Mr. Smith's remarks with regard to the assistance we have received from the Government Departments in connection with this matter. As he has already mentioned, the Government Departments responsible have given us every opportunity of carrying out this experimental work. It is only in connection with passenger carrying vehicles that it has been necessary to obtain special sanction.

With regard to Col. Carr, I can only again endorse the fact that what we have to do to build up our industrial load is to keep on improving the efficiency of our apparatus. Col. Carr has given us examples which are typical of what has been going on for many years with regard to improvements in apparatus which have led to an increased use of gas over other fuels. With regard to bulk heating of steel, he raises the question of low price; but when we get to the heating of steel either in the form of billets or bars, we are up against solid fuel on a price basis. Some of the solid fuel furnaces cannot be classified as inefficient furnaces. One frequently meets solid fuel furnaces with efficiencies of over 50 per cent., and in such circumstances we have to begin to think in terms of 2½d. to 3½d. per therm if we are to deal with heating in large quantities on a competitive basis. With regard to brass melting, of course, the question is purely one of heat transfer. In the case of a smaller pot, we have a bigger conducting surface, and we always find that in the case of brass there is a definite size and capacity of pot which gives the higher efficiency.

There is a point mentioned by Col. Carr which I have not referred to, and that is the possibility of running locomotives on compressed gas. The difficulty there I can foresee is that first of all there is the added weight which would be an important problem. Then I am afraid the question of acceleration would be a difficulty. Nevertheless it would certainly be an interesting matter to look into.

With regard to Mr. Masterman's points, I have already dealt with the question of the economic value of 4d. per therm applying to very large industrial usage; but with regard to improvements in design of apparatus I quite agree that we shall still go on improving designs of furnaces and still increasing our efficiencies. Only during the last fifteen years we have increased from 19 per cent. to 65 per cent. efficiency, and we have still a long way to go. With regard to compression ratios of engines, we have increased our compression ratio to 6·25, which shows an improvement in efficiency of about 3 per cent. If we can run up the compression ratio to 8, theoretically we should obtain just over 9 per cent. improvement in efficiency, but I am afraid that we shall not be able to run quite so high. The limit of compression ratio appears to be about 6½ or 7. As to the difference in power output obtained with different types of air/gas mixtures, I have no figures of CO content, but obviously the combustion was less complete with an inferior mixture. The tests carried out compare the performances of the old and new types of mixer.

The question raised by Dr. Stewart is interesting. I agree that the speed/torque characteristics of an engine running on gas do not altogether agree with those of a petrol engine, and you do not get that running up of the curve to a certain figure and then the curve bending over, which we are so used to with petrol. But at the same time we do find that we are getting very high thermal efficiencies, and it is the very high thermal efficiencies that we are after. I agree that we shall probably improve the results over the whole range of speed as we improve the designs of our mixers, but I can say that the overall efficiency of the engine is now quite good and in many cases is an improvement on what we obtain with petrol.

I was very interested to hear Mr. McLusky refer to the developments which have taken place in Halifax of which I have seen a good deal, and as regards Mr. Haynes' remarks concerning Rotherham I quite agree, as I have already mentioned, that when we come to the large solid fuel fired furnaces automatically dealing with steel billets and large masses, the efficiencies are not quite of a low order. We frequently come across solid fuel fired furnaces which give figures up to 50 per cent. efficiency, and obviously the cost of fuel with solid fuel on that basis is very low.

Ten Years Carbonizing in Vertical Retorts

By J. E. BLUNDELL, M.Inst.C.E., M.Inst.Gas E.,

Engineer and Manager, Carlisle Corporation Gas Department

INTRODUCTION.

In 1919 the Carlisle Gas Undertaking was serving a population of some 52,000 people, confined mainly to the City itself. Districts outside of the City accounted for no more than 360 consumers and 9·5 millions of consumption, while the total number of consumers was 12,385, with 1610 public lamps. From 1922 to 1924 several new housing estates were supplied with gas, and during 1925 the authorized area of supply was increased from 98 to 122 square miles by the inclusion of the parishes of Rockcliffe and Hayton. Since then mains have been extended and enlarged and now supply gas to every centre of population, however small in numbers, within the authorized area, with a definite policy that no reasonable opportunity must be lost of staking out the claim for Gas for every domestic and industrial purpose within the area. As a result of this policy external districts in March, 1932, accounted for 1773 consumers and 39 millions of consumption.

The total length of main at the end of March, 1932, was 134 miles, and the extreme point supplied, the village of How, is $11\frac{3}{4}$ miles from the Works, following the line of main. There is no difficulty in maintaining an adequate pressure throughout the services without boosting.

Gas in such a district as this, is still sold mainly to the domestic consumer. Its increasing use for cooking and heating and for industrial purposes is shown by the fact that whereas in 1920 the maximum daily demand was 1/249 of the annual make it was, in 1930, only 1/274.

In Industry gas is used in the following trades and processes as well as in others which are less clearly definable. (See next column.)

Naturally, slackness in trade generally has had its effect on consumption, and this is shown by the slight decrease in the demand during the past year. That this decrease is not more is due, no doubt, to the natural growth of the domestic consumption.

TRADES.	PROCESSES.
Biscuit manufacture.	Biscuit baking, chocolate making, tin box making, canteen.
Metal box manufacture.	Metal box making, printing on paper and metal, water-heating (gas-fired boiler), drying stoves, varnishing ovens, laundry, canteen.
Silk, artificial silk, and cotton weaving.	Lighting, drying, mercerising, singeing, canteen.
Engineering.	Brass foundry, tool heat treatment, drawing office.
Hat manufacture.	Felt hat finishing.
Steam laundry.	Ironing.

I. THE ROME STREET GAS WORKS.

The original Gas Works, built in 1820, was one of the oldest in the country. It was superseded in 1849 by a Works which served Carlisle with gas until the new Works at Rome Street was brought into operation in 1922. The site was already congested in 1914, but all development was cut short by the World Crisis of that year and when more normal times returned in 1918, the Works was not only considerably exhausted but so fully taxed in capacity, the maximum daily demand having increased from a little over one million c.ft. in 1890 to 1,715,000 c.ft. in 1918, that extension to meet the still growing demand rendered the construction of an entirely new works practically imperative.

The growth of the undertaking is illustrated in a chart prepared in 1922 for and published in the Presidential Address[1] to the North of England Gas Managers' Association, and it was forecast then that the annual make would rise by 1930 to 560 millions c. ft., and the maximum daily demand to 2,300,000 c.ft. The figures actually realized were over 600 millions and 2,273,000 respectively. The chart revised and brought up-to-date is Figure 1.

[1] Gas Journal, 11th October, 1922, p. 93.

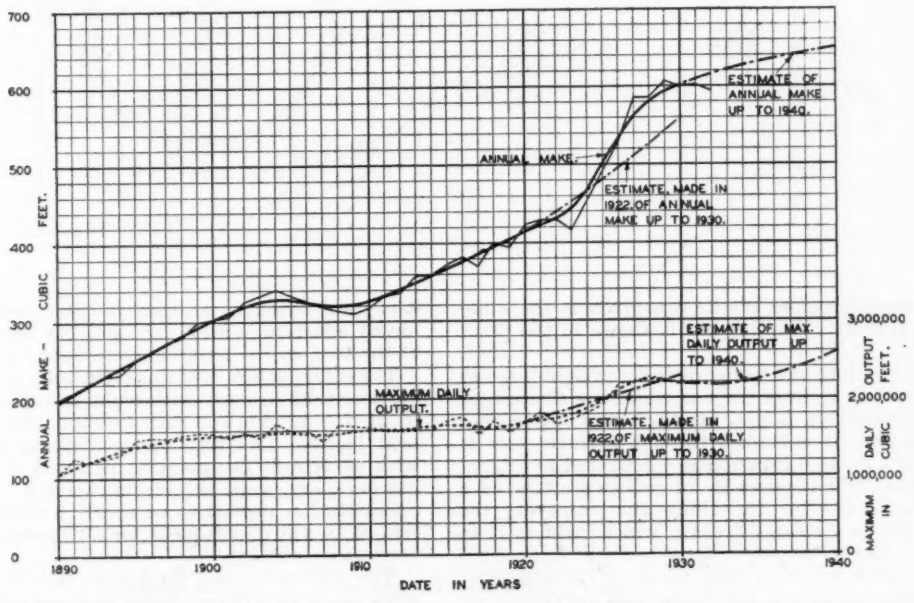


FIGURE 1.—*Chart showing the growth since* 1890 *of the Make of the Carlisle Corporation Gas Department, with a forecast to* 1940.

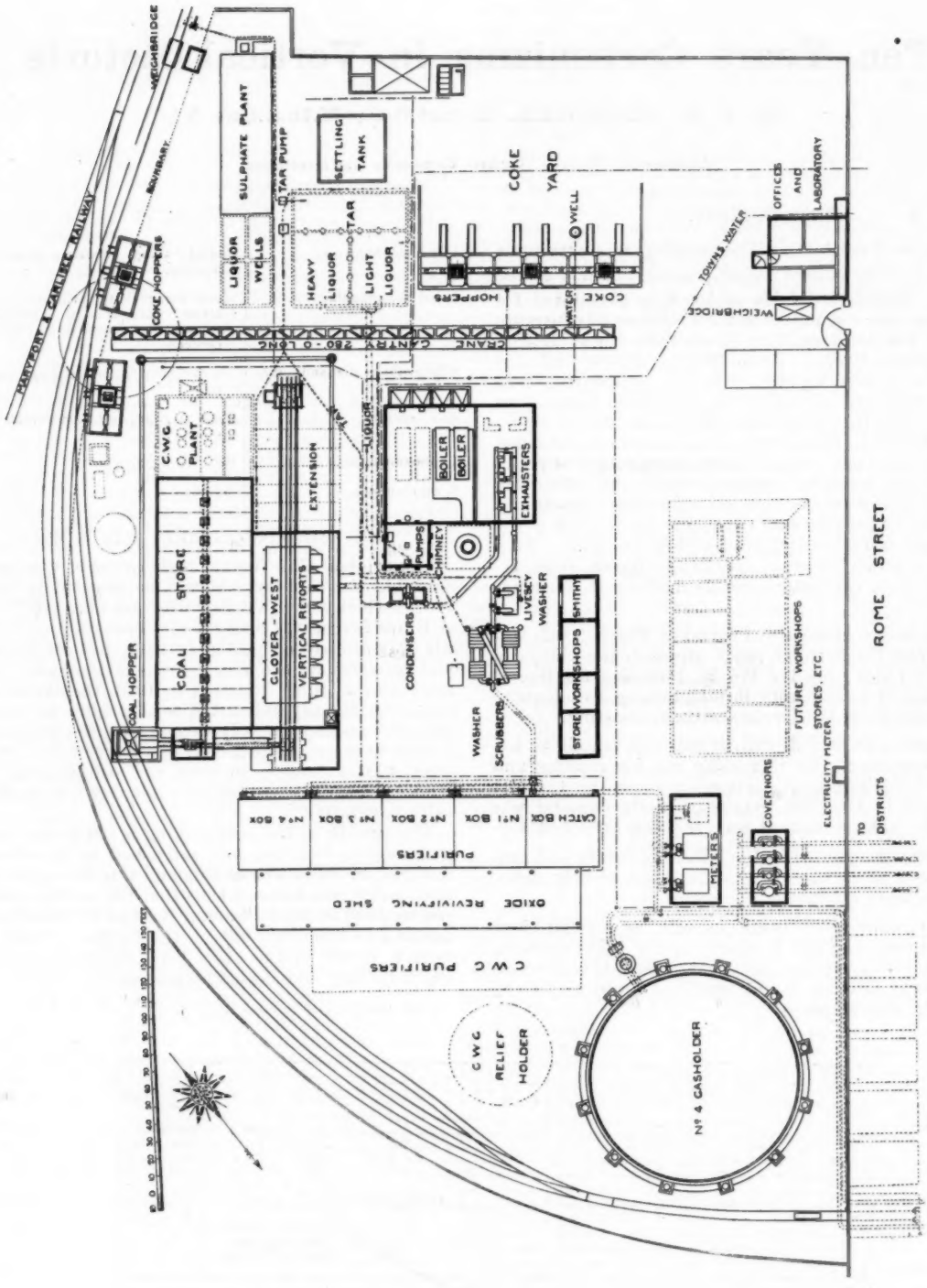


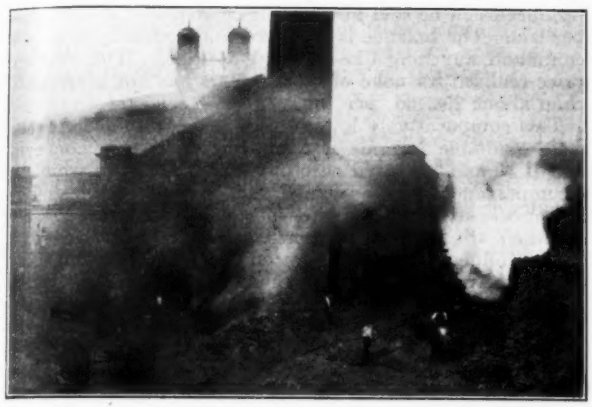
FIGURE 2.—*Plan of the Rome Street Works of the Carlisle Corporation Gas Department.*

A full description of the Works was given in the same Presidential Address. The lay-out is shown in the plan, Figure 2.

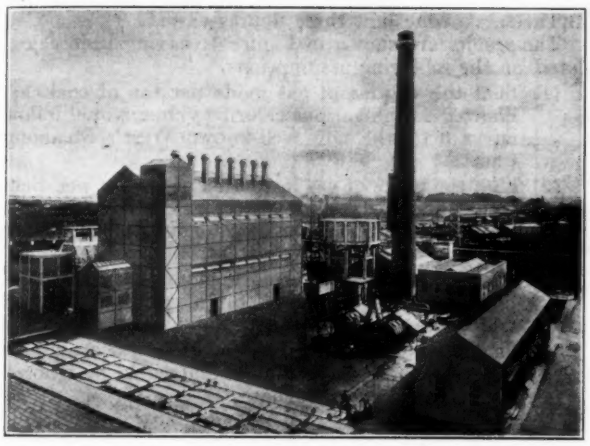
Coal is brought into the works over the weighbridge in the south corner in railway wagons which are discharged into the coal receiving hopper at the north-east corner of the coal store. It is broken through a single pair of claw rollers to 4 in. to 6 in. cube and delivered to a fixed bucket elevator, which raises it for delivery either to a gravity bucket conveyor for filling and emptying the store, or direct to a second breaker which reduces it to $1\frac{1}{2}$ in. cubes for use in the retort house. From this second breaker the coal is fed by a band conveyor through a recording weigher to one of the lip-bucket conveyors encircling the retort bench. These conveyors also receive coke from the retorts and deliver it to an automatic skip-filler at the south-west corner of the coal store, whence it is transported by an electric crane, running on a reinforced concrete gantry, to fixed bar screens over either of the two sets of ferro-concrete hoppers.

The retort bench contains eight settings of Glover-West vertical retorts, each with eight retorts 33 in. by 10 in. by 21 ft. 0 in. long and each with a natural-draught waste-heat boiler. The nominal capacity of the retort bench with all retorts in operation is about $2\frac{1}{2}$ million c.ft. of gas per diem, while the actual capacity with all retorts in operation has proved to be nearly 3 millions. Room was left (it is still unoccupied) for a subsequent extension by four more settings.

The condensing and purifying plant is of 3 million c.ft. daily capacity and comprises condensers of the reversible type in two towers with arrangements to pass the condensing water to the boiler feed, two Lancashire boilers with water-softening plant, two complete sets of ex-



1921.



1923.

FIGURE 3.—*Photographs showing the Old and the New Works of the Carlisle Corporation Gas Department.*

hausters, Livesey washers and rotary washer scrubbers, oxide purifiers in five boxes 40 ft. 0 in. square by 6 ft. 0 in. deep, two station meters, each with a capacity of 70,000 c.ft. per hour, and four station governors, together with tar and liquor wells, mains, and connections.

The new Works was brought into operation in September, 1922, and the improvement in conditions of manufacture was very striking. Perhaps nothing shows it better than the photographs of the old and new Works in Figure 3, both taken while the plants were in full operation. The benefits accruing from the suppression of the periodic emission within the city-boundary of the clouds of smoke and steam incidental to the older method of carbonization, can hardly be exaggerated.

II. THE CALORIFIC VALUE.

One of the first decisions to be made was that of the calorific value of the gas to be manufactured and distributed. The nominal value of the gas which had been distributed during the preceding years was 500 B.Th.U. per c.ft. gross. Not only, however, was the actual quality very variable, but over long periods it had been very considerably reduced. In common with other undertakings, the Carlisle Corporation Gas Department had been obliged by the enforced economy in coal consumption to reduce the calorific value to 450 during 1917 and 1918, so that the consumers were prepared for a reduction in the average value. Indeed, the fact that the new plant easily maintained a quality which never varied more than a very few B.Th.U. on any occasion, gave the consumer so much satisfaction that he was under the impression that the quality had been greatly improved.

A representative analysis of the gas made is as follows:

	P.Ct.
CO_2	3·9
O_2	0·4
C_nH_m	1·8
CO	18·1
CH_4	19·0
H_2	50·7
N_2	6·1
Calculated calorific value	453 B.Th.U./c.ft. gross
Total inerts	10·4 per cent.

III. TECHNICAL RESULTS.

The technical results obtained during the last ten years are given in Table I.

TABLE I.—*Summary of the Eleven Annual Returns of Technical Results for the Period 1st April, 1921, to 31st March, 1932.*

—	Unit.	1921/2.	1922/3.	1923/4.	1924/5.	1925/6.	1926/7.	1927/8.	1928/9.	1929/30.	1930/1.	1931/2.
1	2	3	4	5	6	7	8	9	10	11	12	13
Coal carbonized	Tons	32,813	27,642	24,205	25,645	28,013	32,155	29,773	30,612	31,288	31,471	30,667
Gas (corrected N.T.P.)—												
Annual make	1000 c.ft.	386,477	397,387	453,390	492,157	528,621	585,636	585,782	607,734	600,451	601,194	594,767
Make per ton	C.ft.	11,778	14,376	18,731	19,191	18,870	18,200	19,674	19,850	19,191	19,103	19,394
Calorific value (average)	B.Th.U. per c.ft.	455	471	450	444	447	428	447	449	450	451	451
Thermal value	Therms per ton	53·6	67·7	84·28	85·2	84·3	77·9	88·0	89·13	86·35	86·15	87·47
Coke and breeze—												
Annual make	Tons	24,435	18,760	17,016	17,953	19,006	22,152	19,202	20,216	20,899	20,867	19,933
Make per ton of coal carbonized	Cwts.	14·89	13·57	14·0	13·9	13·5	13·7	12·9	13·2	13·3	13·2	13·0
Coke and breeze saleable	Tons	19,983	13,678	10,792	10,985	10,778	13,068	12,226	12,179	13,789	13,712	13,486
Coke and breeze saleable per ton of coal carbonized	Cwts.	12·2	9·9	8·9	8·6	7·7	8·1	8·2	8·0	8·5	8·7	8·8
Tar—												
Annual make	Tons	1,722	1,675	1,994	1,970	2,296	2,127	2,320	2,442	2,580	2,384	2,497
Make per ton of coal carbonized	Galls.	10·49	12·12	16·4	15·3	16·3	13·2	15·5	15·9	16·4	15·1	16·2
Sulphate of ammonia—												
Annual make	Tons	225	295	344	326	363	395	304	372	378	343	[2] 170
Make per ton of coal carbonized	Lb.	[3] 15·3	23·95	31·8	28·4	29·0	[4] 27·5	22·8	27·2	27·0	24·4	..

PRICE OF GAS.

	1922 s. d.	1932. s. d.	
Within City—Domestic	5 0	3 3,	equivalent to 8 67d. therm
Industrial minimum	4 3	2 6,	,, ,, 6·67d. ,,
Outside City—Domestic	6 0	3 9,	,, ,, 10·0d. ,,
Industrial minimum	5 3	3 0,	,, ,, 8·0d. ,,

NOTE.—The returns are dated 31st March, so that 1921/2 is the last complete year of operation in the old works, and 1923/4 is the first complete year of operation in the new works.

[2] Sulphate of ammonia plant shut down 27th October, 1931.
[3] Coal stoppage for 89 days.
[4] Coal stoppage for 7 months.

In the Report to the Corporation, in which the construction of the new Works was recommended, it was anticipated that there would be an annual saving in manufactory costs of £16,486, or 9·89d. per 1000 c.ft., on the basis of a 400 million annual make. Comparing the figures in Field's Analysis for 1920 and 1930 it will be seen that this anticipation has been more than realized.

—	Gas Sold in Million C.Ft.	Manufactory Costs.	Costs per 1000 C.Ft.
		£	d.
1920	387	27,599	17·11
1930	565	10,649	4 52
Saving per 1000 c.ft.			12·59d.

Inasmuch as there was no considerable change in the calorific value of the gas supplied it may be taken that the costs and saving per therm are proportionate to these figures.

IV. THE COALS CARBONIZED.

The coals carbonized are almost exclusively those from the Cumberland coalfield. During the period under review the established practice has been to investigate the performance in the plant as a whole of all the gas coals which are obtainable at a reasonable price delivered to the Works. Generally, if any new coal is offered which is likely to be suitable, one or two wagons are ordered. These are carefully sampled and analyzed, and put through one or more settings for observation purposes. Should the analysis and the behaviour of the coal in the retort prove favourable a larger sample is ordered, large enough, that is, to permit of a full working test being run through the whole of the plant in operation. Only if this test is favourable is a contract placed for the supply of the selected coal over a lengthy period.

[The Author included in the Appendix particulars of the analyses and tests of 28 unnamed coals. Of these six sorts had been summarily rejected on an unpromising analysis, and 17 tested thoroughly but discarded on grounds of coke quality, cost price, yield, &c. The following are particulars of the five coals now regularly purchased and used. The Author remarks in each case that travel through retort is easy, quality of coke good, and price "average."]

TABLE II.

Number of Sample	18	19	20	21	22
Physical Character	Washed Singles.	Washed Nuts.	Washed Nuts.	Doubles.	Washed Doubles.
Lab. Examination—					
Moisture	1·5	2·4	2·3	1·4	1·4
Volatile combustibles . .	33·2	32·1	32·9	31·1	30·2
Ash	4·3	4·3	5·5	5·5	4·25
Fixed carbon	61·0	61·2	59·3	62·0	64·15
Coke button	Large	Large	Large	Large	Large
Works Test—					
Weight of sample, tons .	81	183	157	93	80
Make per ton in c.ft. . .	19,600	19,575	19,490	19,100	19,573
C.V. B.Th.U. per c.ft. . .	448	450	452	454	448
Therms per ton	87·8	88·1	88·1	86·7	87·5
Curve	4/5	4—	4—	4—	4/5
Equivalents at 450 B.Th.U. per c.ft.—					
Make per ton in c.ft. . .	19,339	19,575	19,750	19,609	19,312
Therms per ton	87	87	88·9	88·2	86·9
Make per retort in c.ft. .	42,740	44,930	45,500	41,547	42,351
Throughput per retort per day in tons	2·22	2·41	2·34	2·17	2·21

A mixture of four of these coals, with a very small proportion, about 9 per cent., of a fifth variety, gave on a three months test in 1928, a make of 21,890 c.ft. per ton at a calorific value some 2 or 3 above 450 B.Th.U. per c.ft.

V. RESIDUALS.

COKE.

The intensive and increasing competition of oven coke, together with the peculiar geographical position and climatic conditions of Carlisle makes the market a particularly difficult one. Only some 50 per cent. of the coke produced can be sold in the district at prices around 25s. per ton. The balance is exported and generally does not command anything like so good a price. The average price realized for coke of recent years has not been more than about 20s. 6d. per ton.

This comparatively low average price obtained for the coke available for sale is a matter for serious concern, and it should be noted carefully that the figure which is of importance is the average sum actually realized per ton of coke available for sale—not, as is sometimes loosely assumed, the nominal price at which some of it is sold.

The influence of this figure on the manufacturing cost of gas at variable calorific values is not always clearly appreciated. Obviously, as the calorific value is decreased from 500 to 400 B.Th.U. the number of therms made per ton increases, but the quantity of coke available for sale decreases. Other things being equal, the price paid for the coal, less the amount actually realized for the residual coke, will determine the cost of manufacture of the gas. But the amount realized for the coke depends both on the quantity available and the average price obtained for it. We, therefore, prepared calculations for every calorific value between 500 and 400 B.Th.U., showing how these figures varied.

The results are shown in Figure 4, having been calculated on the following assumptions.

(1) That the volume of gas made per ton of coal carbonized at the various calorific values would follow curve 3 on the now well-known West's Steaming Chart.[2]

(2) That the make of gas in therms per retort per diem would be constant for all calorific values, so that capital cost and labour cost for a given output of therms would also be constant.

(3) That the weight of coke made per ton would diminish at the rate of 18 lb. per 1000 c.ft of added gas.

(4) That the small return obtained for tar would be offset by losses on ammonia and could be ignored for this particular purpose.

If these assumptions are accepted, it will be seen that the cost of production per therm is strictly proportional to the net cost of coal less the value of the residual coke. The graphs show very clearly that with coal at 20s. per ton, if coke realizes less than 22s. per ton, the cheaper therm is made at the lower calorific values. On the other hand, if coke actually realizes an average of 23s. or more per ton the therm would be made more cheaply at 500 B.Th.U. than at any lower value, even though the number of therms made per ton would be considerably less. But it is also clear that anything which will increase the average return from this residual will reduce the cost of gas production even if the calorific value is reduced to the greatest convenient or practicable point.

The coals carbonized do not produce a large coke so that breaking has proved to be unnecessary. So far it has been screened over $\frac{3}{4}$ in. mesh and not graded in any way. The breeze thus taken out is either consumed under the boilers or shipped. The possibility of altering the practice with regard to the treatment and marketing of coke is one of the problems which has been under consideration for some time.

Coke as a Domestic Fuel.

In the opinion of the Author the best practical summary of the qualities desirable in a domestic fuel is that presented to the National Smoke Abatement Society at Liverpool in September, 1931, by our President-Designate, Mr. R. E. Gibson. These qualities, in so far as they are to be possessed by the solid residual of a carbonizing system, fall into two categories; those which follow from the type and grade of coal carbonized and those which depend upon the system of carbonization. As regards the second category, vertical retort coke seems to fill completely the requirements laid down by Mr. Gibson. Vertical retort coke, at any rate that prepared from any of the coals used in the works under consideration, is easily ignitable. It is dry-cooled in the carbonizing system itself and the ash

[2] Barash and Tomlinson, "Steaming in Continuous Vertical Retorts," Gas Journal, 13th January, 1932, p. 93.

content is quite low. It is clear, however, that if the domestic market in this district is to be retained, the installation of grading machinery, so that coke can be supplied in carefully selected sizes, is imperative.

The Utilization of Breeze.

One way of increasing the average return obtained from the residual coke would be to make better use of the breeze. If this objectionable element in coke production could be more fully utilized for heat and power production on the works itself, it would at once liberate more high-value coke for sale, and, at the same time, solve the problem of its disposal. On the Continent, as is well known, so called " breeze " is utilized for heating retort settings by the use of central producers. But these have not generally recommended themselves to English gas engineers.

In the first place it is necessary to make clear what is meant by " breeze." The loose term, " everything through $\frac{3}{4}$ in. mesh," is not sufficiently accurate for the full discussion of this question. Such " breeze " will contain anything from 30 to 60 per cent. of material which will pass through a $\frac{1}{4}$ in. mesh, and which is better described as " dust." This dust contains a very high percentage of dirt and it is practically worthless as a fuel. As far as definite and published information is available there would appear to be no producer which can be guaranteed to work at a remunerative capacity on breeze containing more than a comparatively small percentage of dust.

It is possible, however, that the ordinary built-in or integral producer with which the English Gas Engineer is familiar, can be readily adapted to the consumption of a fuel which, if not quite " all through $\frac{3}{4}$ in.," will account for practically the whole of the breeze made, with a substantial fraction of the dust.

Experiments, the results of which have been communicated to the Author, have recently shown that a step-grate producer of the type commonly used with vertical retorts has been operated for some weeks under pressure and successfully used fuel passing through $\frac{3}{4}$ in. mesh and containing over 30 per cent. of dust or material passing a $\frac{1}{4}$ in. mesh.

It is possible that there may be sufficient " breeze " in the whole of the coke produced to provide the necessary fuel for the producers. But even if that were not so it would certainly seem to be practical to increase the size of the " breeze " screen to, say, 1 in. mesh, so that all of the coke over that size would be available for sale and would command the top market price.

The Use of Oil in Vertical Retort Practice.

The practicability of the use of oil in vertical retort practice as an effective method of avoiding a surplus in the amount of coke disposable has been investigated.

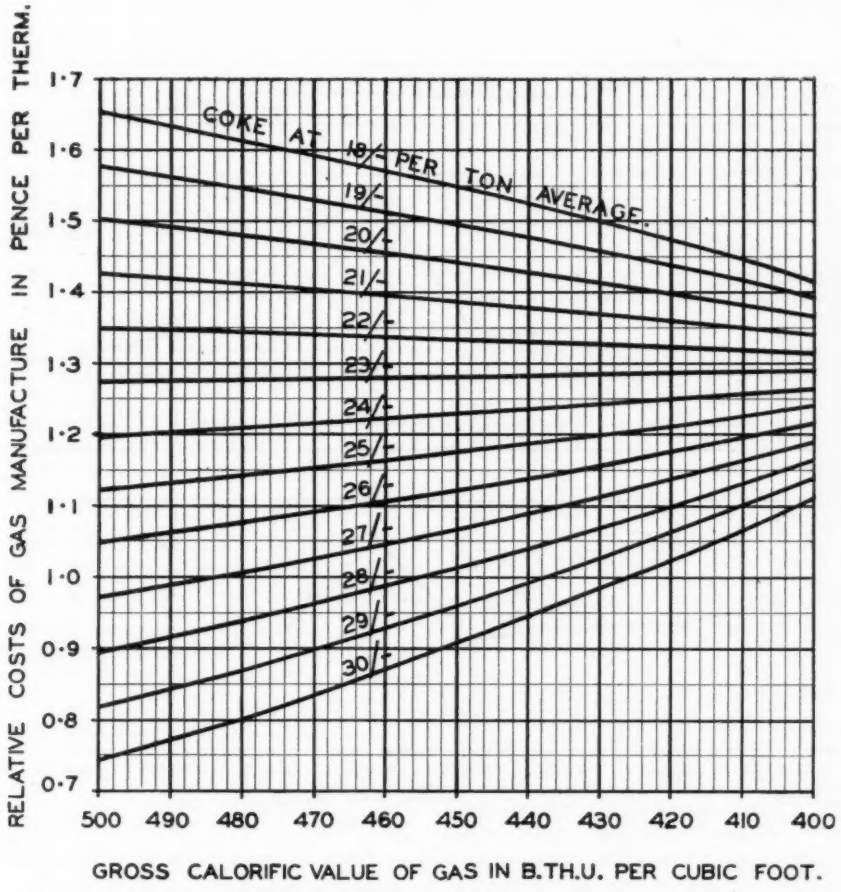


FIGURE 4.—*Graph showing the Influence of Coke Prices on the cost of Gas Production per Therm. Carlisle Corporation Gas Department.*

Actual practice has successfully established the production of a lower quality gas in vertical retorts by increased steaming, resulting in a reduction in the amount of coke for sale, with a restoration of the calorific value of the gas to the standard required by vaporizing oil in adjacent retorts.

But when the question is reduced, as all these problems must necessarily be, to a formula for balance sheet purposes, then the practice can only be successful with oil at a much lower figure than present-day prices and with an average price of coke considerably less than that at present obtainable by most Gas Undertakings. There are, of course, special cases where the practice is a paying proposition.

The question was investigated at Carlisle about 12 months ago, and it was found that by making gas at 400

B.Th.U., that is, by steaming down to that value in the vertical retorts, and enriching with oil gas, the coke for sale could be reduced to 7 cwt. per ton and the gross amount for sale per annum by 50 per cent., but that with oil at present-day prices, there would be no reduction in the cost of manufacture per therm.

Tar.

The question of the best means of disposal of the residual tar has been considered seriously from time to time. In the absence of a co-operative scheme of tar distillery, similar to that in operation in Lancashire, the possibilities are limited to two, (*a*) installing tar treatment plant of some kind, and (*b*) selling the tar to a tar distiller.

It is considered that the size of the undertaking is not such as to justify anything more than the installation of some form of still for the preparation of road tar, but even this does not appear likely to be a paying proposition in Carlisle. Work on the roads in Cumberland is generally confined to the summer months, so that, in addition to the cost of the distillation plant itself, provision must be made for the storage of the tar made during at least six months of the year. Such an expenditure as this would involve has not yet been recommended to the Committee, and the tar has been sold to a neighbouring chemical company under contract at prices ruling at the times of delivery. These prices have varied considerably, but for the last two years over 2d. per gallon has been realized, a figure which compares favourably with that likely to be realized under a co-operative scheme or, indeed, with such profit as might be obtained from a plant installed on the Gas Works itself. At the time of writing 3·34d. per gallon is realized.

Sulphate of Ammonia.

Ammonia is at least as much a problem in Carlisle as anywhere else, and sulphate manufacture was discontinued in October, 1931.

It is a significant, if not ironical, commentary on the industrial conditions in which we are now living, that the most profitable way of disposing of this once valuable by-product is either to evaporate it to the atmosphere or to turn it untreated into the sewers. In this connection it may be well to refer[3] to the statement on this question by Dr. A. Key, Research Chemist of the Liquor Effluents and Ammonia Committee of the Institution of Gas Engineers, in which it is suggested that the latter method is one which need not be "viewed with alarm." It almost leads one to think that probably undue difficulty has been made about the discharge of effluent liquor in this way.

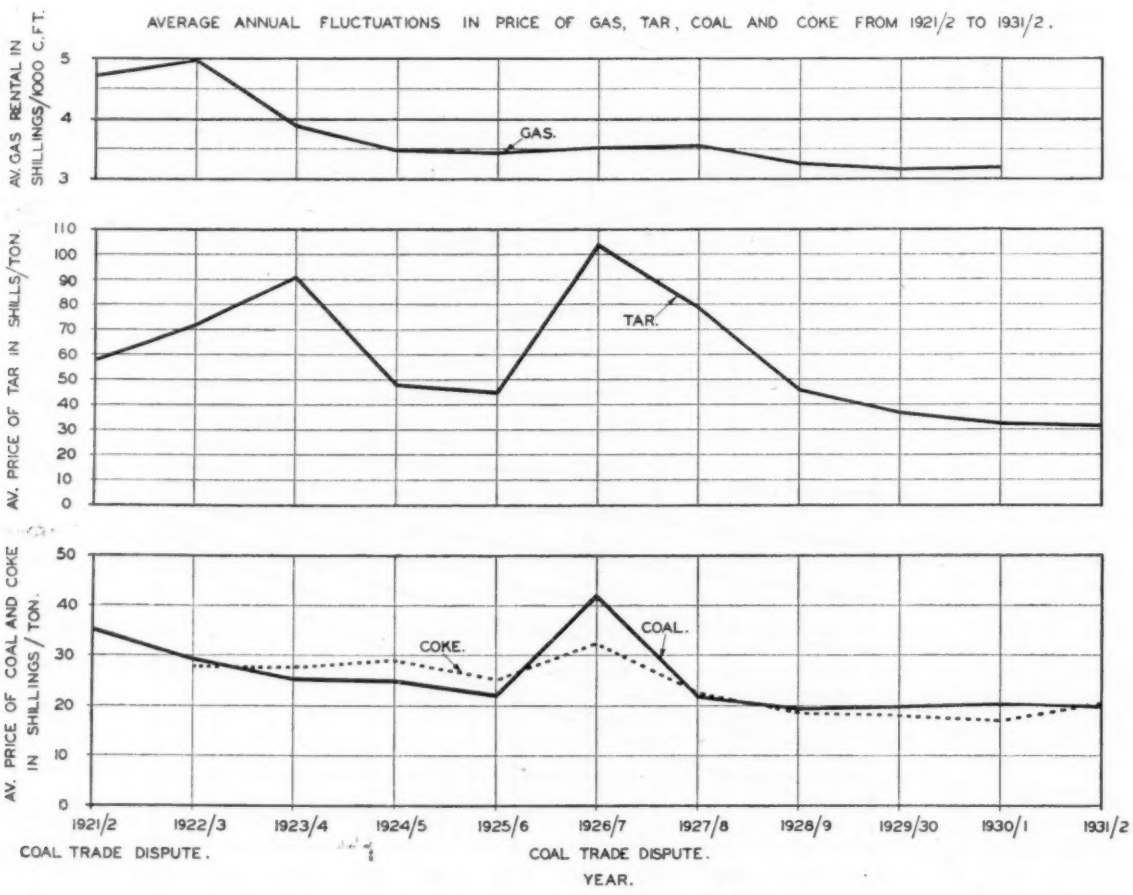


Figure 5.—*Average Annual Fluctuations in the Price of Gas, Tar, Coke and Coal from 1st April, 1921, to 31st March, 1932. Carlisle Corporation Gas Department.*

VI. MANUFACTURING COSTS.

Figure 5 shows the annual variations in prices paid for coal and the average prices obtained for gas, coke, and tar during the period under review.

At the present time the average cost of coal at the Works is about 20s. per ton. Coke realizes an average of 20s. 6d. per ton, and the net quantity sold is about 8½ cwt. per ton of coal carbonized. Tar is selling at an average price of 3·34d. per gallon and there are about 16 gallons available for sale per ton of coal carbonized. Ammonia has disappeared from the balance sheet.

The maximum daily demand of 2,161,872 c.ft. is met by the output of 48 retorts. The total labour cost per week is £52 16s. 6d. including the whole of the labour em-

[3] Gas Journal, 13th April, 1932, p. 83.

ployed within the retort house together with the whole of the handling of the coal from the time it enters the works to the point at which the coke is delivered to the storage hoppers. Power at 1d. per unit costs approximately £5 11s. 8d. per week.

On this basis, Table III. analyses in detail the total carbonizing cost per 1000 c.ft. and per therm.

TABLE III.—*Carbonizing Cost at the Rome Street Works of the Carlisle Corporation Gas Department at the rate of 2,161,872 C.Ft. of gas per Diem, or 15,133,104 C.Ft. per Week.*

Coal carbonized[4] . . . 2,562 tons.
Gas made[4] . . . . . 50,049,000 c.ft.
Average make per ton[4] . 19,540 c.ft.
" " " retort[4] 45,039 by 48 retorts = 2,161,872 c.ft. per day.

—	Per Week.	Per 1000 C.Ft.	Per Therm.
	£	d.	d.
COAL—			
$\frac{15,133,104}{19,540}$ = 774 tons, at 20s. . . .	774		
RESIDUALS—			
Coke (at 8½ cwts.):			
329 tons at 20s. 6d.	337		
Tar (at 16 galls.):			
12,384 galls. at 3·34d.	172		
Total residuals	509		
NET COST OF COAL	265	4·20	0·93
LABOUR—			
6 beds, 3 stokers per shift = 48 retorts, = 2,161,872 c.'t per day	£ s. d.		
3 leading stokers at £4 1s. 3d. . . .	12 3 9		
6 stokers at £3 16s. 3d.	22 17 6		
3 cranemen at £3 10s. (⅔ time) . . .	7 17 6		
1 coal elevator man and greaser at £2 15s. 1d.	2 15 1		
1 engine driver at £2 17s. 8d. (½ time) .	1 8 10		
1 shunter at £2 15s. 1d. (⅓ time) . .	1 7 7		
1 bricklayer at £3 6s. (⅔ time) . . .	2 9 6		
1 labourer at £2 9s. (⅔ time)	1 16 9		
	£52 16 6	0·83d.	0·18d.
POWER—			
1340 units at 1d.	£ 5 11 8	0·09d.	0·02d.
TOTAL COST OF CARBONIZING . . .		5·12d.	1·13d.

[4] See Table VI.

VII. THE CARBONIZING PLANT AND ITS EQUIPMENT.

General.

Some of the details of the retort house plant call for comment in the light of ten years experience. The refractory materials of the retorts and settings have proved eminently satisfactory. The coals carbonized fortunately do not call for any very high temperatures in the combustion chambers. Average readings of the pyrometer are as follows, the top of the retort being at the top of the table.

TABLE IV.—*Average Temperatures in Retort Settings.*

	°C.
3rd circulating chamber.	1000
2nd " "	1130
1st " "	1250
5th combustion chamber	1275
4th " "	1290
3rd " "	1300
2nd " "	1300
1st " "	1320

[See also Figure 6.]

The original retorts were built in siliceous material containing from 88 to 89 per cent. of silica. Of the original retort bench which commenced gas-making in September, 1922, the retorts in two settings were renewed in 1928 in silica materials with about 95 per cent. silica content, the retorts in two more settings were renewed in 1929 in siliceous material with about 91½ per cent. silica content, and in two further settings in 1931 in the same class of material. There are thus still two settings in which the retorts have not yet been renewed.

Life of Retorts.

The unit of operation has been the setting of 8 retorts. It may be objected that, even for a Works of this size, that is a large unit, but such an objection would show the usual misapprehension of the essential difference between the continuous and the intermittent systems. In practice there is no sharp line between, say, six units in operation and seven. The continuous retort is so easily controlled that there is no difficulty at all in meeting an increasing demand by, first, increasing the production in the six units to the maximum and then bringing into operation the seventh unit, at the same time reducing the production of the whole to just what is necessary to meet the demand. In other words, the difficulty, that when one unit goes out of production there is a drop of 16, 20, or 33 per cent., is non-existent with the continuous system; the production can be readily adjusted exactly to the demand without any " jump " at all.

The life of the individual settings, therefore, corresponds to the life of the retorts. A systematic resetting of approximately 2 settings per annum was initiated in 1928, in the summer of which year the retorts in settings 7 and 8 were renewed. Settings 3 and 4 were renewed in 1929. Settings 5 and 6 were not reset until 1931, although they had already given over 2000 working days. And it is clear that it will not be necessary to deal with settings 1 and 2 until 1933. The life of the retorts is set out in Table V.

TABLE V.—*Life of Retorts.*

Setting No.	Date of Resettings.	Working Days.		
		Before Resetting.	Since Resetting.	Total.
1	2	3	4	5
1	..	1430	..	1430
2	..	1770	..	1770
3	1929	1520	510	2030
4	1929	2030	550	2580
5	1931	2480	210	2690
6	1931	2500	210	2710
7	1928	2030	450	2480
8	1928	1960	450	2410

It is clear that these retorts have given good service. There is much to be said for the view that to " nurse " retorts to give a long life at the expense of production per retort or yield per ton is false economy. It should be noted, however, that the Cumberland coals are not only readily carbonized, generally at comparatively low temperatures, but the selection of the coals actually used has been directed to those which give good results combined with easy working through the retort.

A working life of 2000 days with a throughput of 2¼ tons per day, which may be taken as the average performance of these retorts, in round figures, is equivalent to a duty of 4500 tons of coal carbonized during the life of the retort.

The Lip Bucket Conveyors.

These conveyors were some of the first of their type to be produced in this country, and their low maintenance cost is very gratifying, especially when it is considered that they have handled 279,378 tons of coal and (reckoned at 13½ cwt. per ton) 188,580 tons of coke, or about 468,000 tons of the two materials combined. The actual amount spent on these conveyors for repairs is £222, so that the cost of maintenance per ton of material handled has been only 0·114 pence. The repairs have consisted of a proportion of bushes and runner wheels and some of the bearings and sprocket wheels. The original links and pins are still doing good service and all the buckets are still intact. The stamped steel side links are particularly hard-wearing and their comparatively high initial cost would seem to be fully justified.

The Recording Weigher for Coal to Retort House.

A general and well-deserved criticism of Gas Works design has been that there is insufficient provision for weighing and measuring the raw materials and products to and from the several pieces of manufacturing apparatus. Compared with a modern electricity generating station the average Gas Works of similar capacity makes rather a poor show. It is time that each considerable unit of production in the Gas Works was at least as well equipped with measuring apparatus as each and every boiler and dynamo on the electricity works generally is.

In a self-contained homogeneous plant like the one

under consideration, the problem of making such adequate provision was comparatively easy of solution. There is only one stream of gas, so that production is known from hour to hour. The weighbridge measures gross coal to works and the recording weigher measures coal to retort house. The coke is not so well served. With so abrasive a material it was not considered practicable to pass it through so expensive a machine as the hopper weigher, and the alternative, some form of conveyor weigher, was not reputed at the time of building to be sufficiently accurate to be worth installing; it is probable that had the more recent designs been available then, a different decision might have been arrived at.

Certainly, the recording weigher for coal has enabled a very close control to be kept over carbonizing results, as shown in the Weekly Carbonizing Reports, Table VI., for the month of March, 1932, which are accurate within limits sufficiently close for practical purposes.

The Automatic Coke Skip-Filler.

Another detail of some interest in the equipment of the plant is the automatic skip-filler, by means of which coke is transferred from the lip-bucket conveyors of the retort house to the self-tipping skips of the crane.

The weight of the skip entering the guides (see Figure 7) depresses a balanced lever, causing the chute to move downwards, emptying the measuring chamber and filling the skip with coke. When the full skip is elevated by the crane, the balanced lever is reversed, closing the measuring chamber and opening the radial door from the main hopper, filling the measuring chute for the next supply.

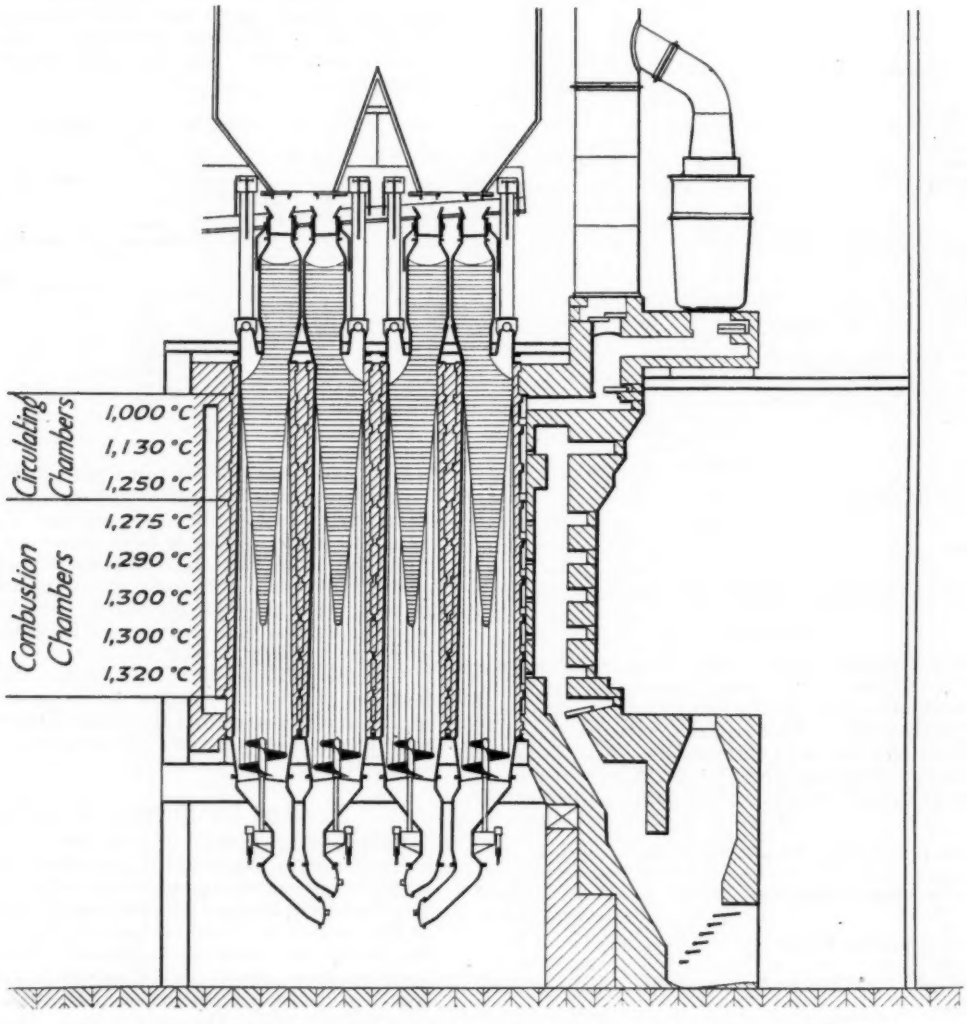


Figure 6.—*Sectional View showing circulating and combustion chamber temperatures. Carlisle Corporation Gas Department.*

Table VI.—*Weekly Carbonizing Reports for the Month of March, 1932.*

—	Units.	February 28–March 6.	March 6th–13th.	March 13th–20th.	March 20th–27th. (Holy Week).
1	2	3	4	5	6
Coal carbonized	Tons	660	655	643	604
Gas made, corrected	1000 c.ft.	12,904	12,883	12,503	11,759
Calorific value, average	B.Th.U. /c. ft.	451	450	452	451
Make per ton	C.ft.	19,545	19,700	19,445	19,468
Therms per ton on declared value	Therms	88·0	88·6	87·5	87·5
Retorts in action	..	280	286	280	265
Make per retort, per day	C.ft.	46,085	45,045	44,653	44,373

The skip thus receives its supply of coke from the hopper automatically without any operation on the part of the crane driver other than that of lowering and raising the skip into the guides.

Maintenance.

Details of the cost of maintenance for nine years are available for comparison. The actual expenditure under this heading for the maintenance of the retort bench, retort house equipment, coal and coke handling is shown in the following Table VII.

The last three columns are calculated on the carbonization of 279,378 tons of coal and the make of 5398·5 million c.ft. of gas during the period covered by the figures in the first column.

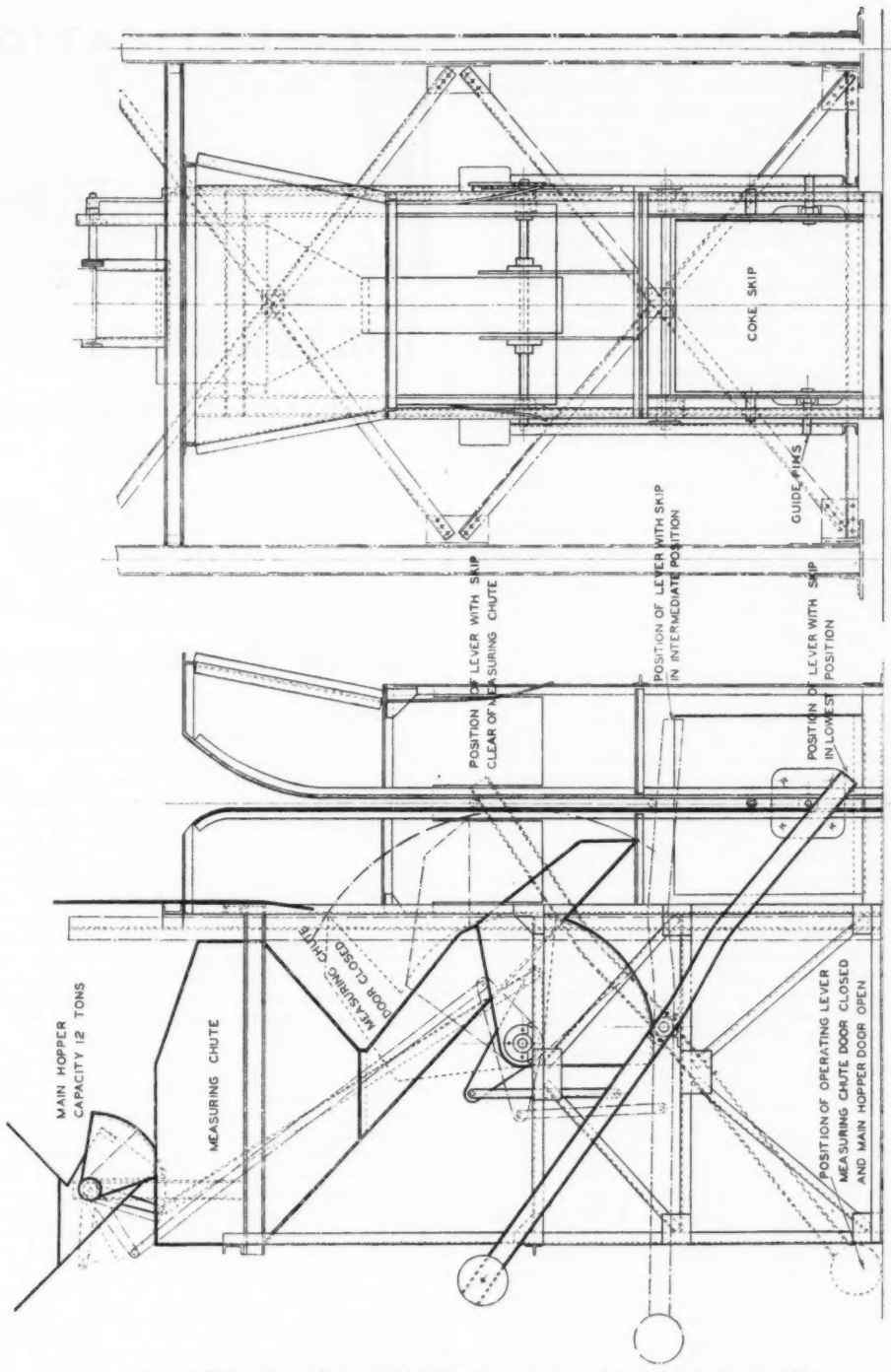

COKE SKIP
GUIDE PINS
POSITION OF LEVER WITH SKIP IN INTERMEDIATE POSITION
POSITION OF LEVER WITH SKIP IN LOWEST POSITION
POSITION OF LEVER WITH SKIP CLEAR OF MEASURING CHUTE
MEASURING CHUTE DOOR CLOSED
MAIN HOPPER CAPACITY 12 TONS
MEASURING CHUTE
POSITION OF OPERATING LEVER MEASURING CHUTE DOOR CLOSED AND MAIN HOPPER DOOR OPEN

FIGURE 7.—*Automatic Skip Filler. Carlisle Corporation Gas Department.*

TABLE VII.—*Expenditure on Maintenance from September, 1922, to March, 1932.*

Coal carbonized = 279,378 tons. Gas made = 5,398,490,000 c.ft.

Description.	Material.	Labour.	Totals.	Per Ton of Coal Carbonized.	Per 1000 C.Ft. of Gas Made.	Per Therm.
1	2	3	4	5	6	7
	£	£	£	d.	d.	d.
Retort setting—						
Including complete resetting of 48 retorts, with miscellaneous repairs over the whole period	6,891	580	7,471	6·42	0·33	0·07
Producers—						
Brickwork, relining and general repairs	217	245				
Ironwork	291	20				
	508	265	773	0·66	0·03	0·01
Waste-heat boilers	357	20	377	0·32	0·02	..
Bench bracing—						
Including bunkers, skips, and driving gear	973	131	1104			
Bench fittings—						
Including mouthpiece doors, safety bolts, &c.	613	20	633			
Lift	162	10	172			
			1,909	1·64	0·08	0·02
Coal and coke conveyors	651	116	767			
Crane	473	80	553			
Electrical equipment	44	..	44			
			1,364	1·17	0·06	0·01
Total	£10,672	£1222	£11,894	10·21	0·52	0·11

CONCLUSION.

I make no apology for having confined the foregoing remarks very strictly to the carbonizing experiences and the problems arising in, and immediately around, the retort house. However true it may be that the prospects of gas as the fuel of the future depend very largely on the development of salesmanship, it remains as true as ever that the production of a cheap Gas is to be achieved first, and mainly, in the retort house. And I am not one of those who think that the developments in carbonization during the last twenty-five years, rapid and even spectacular as these have been, have exhausted the possibilities in that direction. But no amount of improvement in the position of residuals, no changes in the design of auxiliary plant, are likely to have anything like the same effect on the cost of production of Gas as economies and developments in the retort house itself. And, finally, however much may be done in the organization and development of show-rooms, canvassing, publicity, and other forms of salesmanship, urgently necessary as these are, Gas cannot be sold even in those fields where it should occupy the premier position, unless it can be made at a competitive price. The order of things, it seems to me, is, first, that the lowest cost of manufacture per therm must be achieved, second, the most efficient application of the therm to its duty in the household and in industry, and third, the well-backed-up efforts of the salesman who brings it to the notice of the public.

DISCUSSION.

The PRESIDENT: Before the discussion commences I should like on your behalf and my own to offer our sincere thanks to Mr. Blundell for the valuable paper he has presented to the Institution this morning. It is an eminently practical paper covering a period of ten years, and is full of valuable records of the work accomplished during that time.

Mr. R. E. GIBSON (Liverpool): Mr. Blundell's excellent paper contains many facts and figures which will no doubt raise discussion this morning, but I only intend to touch on one matter in particular—viz., domestic fuel. Before getting on to that subject, however, I should like to congratulate Mr. Blundell on the very good results he has obtained at Carlisle. It is one thing to obtain good results under test conditions when everything is in apple-pie order and the retorts are in good condition, but it is another thing to get good results over such a long period as ten years, and I think Mr. Blundell is to be congratulated.

HIGH-TEMPERATURE DOMESTIC FUEL.

With regard to his remarks on domestic fuel, Mr. Blundell has placed such fuels in two categories—viz., those which depend on the grade of coal used, and those which depend on the system of carbonization adopted. While agreeing in the main with what he has said, I do not fully agree, because these two factors are interwoven and interdependent. As many of you are aware, we at Liverpool have been producing a special smokeless fuel named "Dryco," made in horizontal retorts with a certain blend of coals, and it is a fuel which has proved very satisfactory. We tried to produce the same fuel by carbonizing in vertical retorts, but I am sorry to say that the results were disappointing. That, however, was probably not the fault of the vertical retorts, because we have experimented more recently with vertical retorts.

I was interested to hear that Mr. Blundell finds that his vertical retort coke as made at Carlisle seems to fill the requirements of a good domestic fuel, including ease of ignition. I think that may be quite all right. We have also produced a good domestic fuel from vertical retorts by careful selection of the coal used and by giving special attention to the control of carbonization and other factors, but we found that our ordinary vertical retort coke did not quite fill the bill with regard to a really first-class satisfactory domestic fuel; and that is why we tried our experiments with horizontal retorts. Since then, of course, we have been successful, but, as I say, it depends very much on whether the right coal is used. It may interest you to know that "Dryco," of which we have sold thousands of tons, has displaced the use of raw coal in a great many households. It costs more to produce than ordinary coke, and we are able to get about £1 per ton more for it than if we exported coke. We have taken that coke from the surplus and found a new market for it, and therefore it is very helpful in our business. Of course, if we make the production of solid smokeless fuel our first consideration, there is no doubt we can provide what is required, but it would be at some loss in gas production, perhaps, and in the formation of breeze and one or two other matters; but if we can get a price which will compensate us for these losses, I think it is well worth while. If the Gas Industry does not take this matter of the production of smokeless fuel in hand, I believe other people will take it up and we shall not be in the picture.

Our experience at Liverpool has clearly demonstrated that first-class solid smokeless fuel can be produced by high-temperature carbonization if the necessary care is taken. It can be produced in either horizontal or vertical retorts, but due regard must be paid to the right selection of coal, ash content, dry quenching or cooling, and the suitable grading of the fuel.

AN EXCELLENT RECORD.

Mr. F. P. TARRATT (Newcastle-on-Tyne): I should like to say a few words on the paper, which is an excellent production and covers a period of ten years, which is rather unusual. Mr. Blundell was very fortunate in going to Carlisle and finding the conditions he did there. He had the opportunity of laying out a new works on a virgin site, and he had the courage to abandon his old site entirely. He has been more than justified, as is seen by the excellent report he is able to put before us to-day. It is not the good luck of many of us to be able to lay out a new works in their entirety. I have never had that good fortune, although I have had half sites to build on and sites to remodel. I have looked through Mr. Blundell's figures with regard to repairs and maintenance, and I must say they are exceedingly good. They are, in fact, a little better than my own, but I am rather hoping his will go up when he has set two more of his retorts! He has not yet really completed the full extent of his re-setting, and when he has done so I think he will find the cost of repairs and maintenance will be just a shade higher. But that is by the way.

With regard to carbonizing figures, of course it is not easy to compare one works with another. So much depends on what items come under this heading. I have endeavoured to check these figures over; and they certainly are exceedingly good. In my case we have a matter of 22 retorts, and even working with that number of beds—which, of course, gives us a distinct advantage with regard to supervision, &c.—the author's figures are better than mine. That is mainly attributable to the wonderful selection of coal which Mr. Blundell is able to secure. The list of coals he gives is very interesting, and I can assure you they are very different coals from what I have to deal with in Durham and Newcastle. Ours are all unscreened coals, but Mr. Blundell has coals, I see, with 33 per cent. of volatile matter (average), a low ash content, easily steamed, and giving 86 therms per ton. That is something I have never been able to experience. Our coals have a very much higher ash content, unfortunately. They are all Durham

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coals, very difficult to steam. We find that if we steam them and keep our gas down below 500 B.Th.U., the quality of the coke suffers very materially, which is a thing we cannot countenance for one moment. If we get 75 therms per ton we are fairly well satisfied with 500 B.Th.U. gas.

Horizontal and Vertical Retorts.

Mr. Blundell mentions that in laying retorts off it is usual to maintain an equivalent output of gas from the smaller number of retorts in use, but I am afraid he would not have that experience if he had to operate with Durham coal, which is very strongly coking and with which there is very little opportunity of increasing either the speed with which the coal goes through the retorts or increasing the steam put through the retorts; and these are very material factors. Mr. Blundell also has a very good figure for tar. I do not know to whom he sells his tar, but it is a wonderful price to get—3·34d. per gallon, 16 gallons to the ton, and vertical retort tar at that! With all due respect to vertical retort tar, it seems to me to be an extraordinarily good price, and he has a very wonderful market. Comparing vertical retorts with horizontal retorts, I have rather come to this conclusion—and I have had a fair experience with both—that there is very little in it with regard to the results I can obtain from one or the other. I have found that the good figures we have been able to get from our vertical retorts have been a very strong incentive to the managers of the horizontal retort works to bring their plants into line, and it is a question of a decimal point or two between the one and the other. Some consumers prefer horizontal coke and absolutely specify it, whereas other consumers like vertical coke.

I notice Mr. Blundell refers to the quality of his siliceous material, and he seems to have changed a little bit. I suppose he has an open mind, as I have, as to the best material for these retorts. I am not letting out any secret when I say we certainly have had trouble from erosion; and I should like to know if Mr. Blundell has had that trouble with his retorts—some of you may call it spalling—in the third or fourth chamber down. If we could get a class of material to stand up to these conditions, which are very exacting, I think retort repairs would show a very distinct improvement. The remainder of the retort is absolutely perfect, but the third or fourth chamber down causes trouble, and you know that to effect the repairs you have to take off three or four sections, and the others suffer very materially when you do this. Mr. Blundell's temperatures are much lower than mine. I have to work with much higher temperatures than he does when carbonizing our coal. He is also to be congratulated on his low inerts; 10·4 per cent. is a very good figure with a 450 B.Th.U. gas. I am afraid I cannot approach that. There is one other point, and that is with regard to the quantity of coke sold—viz., 8½ cwt. I rather hesitate about this. I feel I must have nearer 10 cwt. of coke, but I should like to know about the breeze actually in the coke as it comes from the retort. I know he will say it depends on what you mean by breeze. I say it means small stuff that is practically unsaleable and cannot be used except under your boilers. What is the author's figure for that? I should like to join the other speakers in thanking Mr. Blundell for his paper.

Coke "Purified" in Vertical Retorts.

Mr. W. B. McLusky (Halifax): If Mr. Blundell had given us nothing but the "conclusions" in his paper I think we should have said these constituted a paper in themselves. I do not propose to criticize the paper. I have nothing but praise to offer. I knew this boy Blundell when he was at the Southport Gas-Works. He was a very intelligent youth. I was tremendously impressed by his work afterwards at Macclesfield. I remember a very eminent gas engineer saying to me, "Do you see that a young man at Macclesfield is claiming a production of 17,000 c.ft. per ton of coal carbonized? Absurd; impossible; it is not in the coal." [Laughter.] I, however, ventured a warning that we should accept the results of this young man with greater respect. [Renewed laughter.] In 1917, when Mr. Blundell presented his paper at Manchester, my friend, Mr. Laurence Hislop, who was present, said, "I am going home to reproduce Blundell's results"—and he did. He had got precisely the same results. That shows that Mr. Blundell was scientific. The pioneers in our Industry have faced difficulties with determination; if they do not provoke criticism they excite envy. [Laughter.] But always the Industry benefits. The builders and users of horizontal retorts have derived benefit from Mr. Blundell's work. They said, "We will not let this young man beat us." The vertical retort has raised the standard of coke. Vertical retort coke generally contains less moisture and less ash than coke produced from coal of equal quality in a static charge—ovens or horizontal retorts. I have said before, and I repeat, that the continuous vertical retort purifies the coke. If you examine the ash from a continuous vertical retort you find in some cases that the greater proportion of the ash is in the dust. The specific heat of the ash being different from the specific heat of the coal, the one parts from the other to a large extent within the retort. The pre-washing of coal is futile as regards the ash contained in the natural partings. Such washing can only remove extraneous impurities. Much of the foreign matter is imprisoned in the coke discharged from horizontal retorts, and may be reduced by crushing, grading, and washing the coke.

We have had, I believe, a more uniform quality of gas in the mains since the advent of continuous vertical retorts, and less sulphur in the raw and in the finished gas. The scientific "continuous" production system simplifies the composition of the crude gas and makes it more amenable to washing, scrubbing, and purification. Even the best coal is not good enough if it is not carbonized uniformly and "continuously;" even the best raw gas is not good enough if it is not simple in its composition and amenable to treatment by hot washing, cold washing, scrubbing, and purification. In Halifax we adopted continuous vertical retorts not because we were dissatisfied with horizontal retorts but because we wanted a purer stream of gas in the town; and by persistent effort over a period of years we have got the sulphur down to a low figure.

May I now say a word or two rather personal. I think that this Industry is neglecting its duty in not marking with some reward or recognition efforts such as those which Mr. Blundell has put forth and which have been of tremendous benefit to the Industry generally.

Combining Two Difficulties.

Mr. S. Tagg (Preston): I desire to associate myself with the commendation which previous speakers have bestowed upon Mr. Blundell's paper, and his achievements at his new works. It is ten years since he was called upon to make the decisions he refers to regarding the declared calorific value. Since then I notice he has had a considerable increase in his sales of gas, and that he has spent during that period something like £200 per million for new business by extensions to mains and services, &c. He has improved his load factor, due, of course, to the increased cooking load. He is now faced with the fact that coke is a less valuable residual than it was at the time the works were built, and he is also faced with the fact that lower thermal costs can be obtained if his declared value is lower than 450. In other words, he is faced with the problem which confronts us all from the manufacturing point of view. We require a low-grade gas, a gas of lower thermal value, which at present values is the cheapest gas to produce, but we are always confronted with difficulties on the distributing side with the peak load growing, particularly with the cooking demand, to the extent it is, and it is difficult for us to give adequate pressure over the whole of the district. An interesting figure in my district which I extracted this year is that the maximum load on Sunday, due to cooking, is exactly one-fifth of the day's output; the maximum hour represented exactly one-fifth of the day's output.

Therefore, I want to make a suggestion with regard to combining these two difficulties—viz., that of manufacturing a low-grade gas and distributing an average grade gas—because Mr. Blundell refers to the inerts. I notice Mr. Blundell's inerts are low, something like 10 per cent. Of course, if these inerts can be limited, if the removal of the inerts can be effected, his calorific value can be raised from 450 to 500. That can be brought about in two directions—first, by close attention to reducing the nitrogen content, and, secondly, I think it will repay everyone closely to study the pressures at the top of the retort, particularly during the period when the coke chambers are being emptied. I know that close attention there will effect a reduction in the nitrogen content. The CO_2, mentioned in the paper, is a fair average; it is 3·9 per cent., and as a matter of fact it is a lower figure than we are obtaining at our works. That is very largely a question of the exact control of temperature in the lower sections and of relating throughput of coal to the quantity of steam passing. I do feel that there is a possibility that it will repay us to remove to some extent, if not wholly, the CO_2 content of the gas, and I suggest the possibility of doing it by means of washing with an alkaline carbon, a process which is in use in the preparation of liquid CO_2 on a commercial scale. In that case a potassium or sodium carbonate is used and a bicarbonate is formed. This bicarbonate is decomposed by heating, thus completing the cycle and effecting the elimination of the CO_2 with very little loss of the washing solution. That, of course, is the Koppers process used abroad, and I believe it was tried on the crude gas at Southport: but instead of re-heating the washing solution, which, of course, contained sodium sulphide and potassium sulphide, it was actified by blowing air through from a separate

vessel. I believe it is a commercial proposition to wash with carbonate and so reduce the CO_2 content to increase the calorific value. As a matter of fact, if you had something like 4 per cent. CO_2 in your gas, and it could be washed out, apart from the advantages of the sulphur compounds and a reduction of the specific gravity, the calorific value would be raised by something like 18 B.Th.U., and if this could be effected at a reasonable cost it would allow the production of a higher thermal yield from the coal, and I believe would go some little way to help us in this problem of delivering the gas at a reasonably high calorific value, and yet obtaining the most efficient costs in production.

Net Return for Coke.

Mr. F. B. Richards: I feel that this paper is a particularly valuable one in that it gives experience over a long period of years, and results obtained over a long period of time are naturally of much greater weight than those obtained over a short time. The author brings out several points to which I should like to refer. Particularly does he bring out the fact that the aim and object is to produce the cheapest possible gas, and that two of the most important factors determining the cost of making gas are the cost of maintenance and the net return obtainable for the coke. Dealing first with the net return obtainable for coke, the author mentions that in his district he finds it practicable to sell about 50 per cent. of his output at a price of about 25s., and that his average price is of the order of 20s. per ton. I would like on that question to ask whether it is a better policy to give your gas consumer every possible inducement to consume the whole of the coke produced in the district, or whether it is a better policy to maintain a certain price in the district and—I do not wish to use any offensive words—to dump the surplus coke at some very low price outside the district. The author emphasizes the need for stating everything on the basis of the average price obtained, and not of stating the local price.

On the subject of the net return for coke the possibility of using breeze is naturally a thing which first comes to one's mind, and a good deal of experience is accumulated to bear out the point referred to by the author in his paper —namely, the practicability of using a good deal of breeze in producers for heating the settings. One likes to collect as much information as possible on this subject; there are a good many installations of mechanical producers, particularly on the Continent and in America, for heating the settings, and usually the reason for installing that type of producer is stated to be its affinity for breeze. I suppose there is no term which is more loosely used than the term "breeze," and after close investigation of a very large number of mechanical producer installations I have discovered that in no single case is what I understand as breeze being burned. In practically every case what is called breeze has had the dust taken from it, and one of the factors which affects the affinity to burn breeze is undoubtedly the grading of that breeze. If, for example, the dust under, say, ¼ in. was removed you have not what we call breeze, but a very good fuel and one which can be used very readily on step grates. A certain proportion of dust below ¼ in. can be burned, and the success obtained in burning breeze, and the output obtained per square foot of grate surface, are undoubtedly due very largely to the percentage of the fuel which is below ½ in. Any engineer who can give us first-hand experience on this matter would, I am sure, be listened to with very great interest and attention at this meeting. Taking one or two instances that have come under my own observation, there is one case where a very large plant was run for a whole week with fuel passing 52 per cent. through ¾ in., using step-grate producers. Another plant ran for a considerable period of time with fuel which passed 50 per cent. through ¾ in. and 25 per cent. through ½ in. There was yet another plant where 40 per cent. of the fuel was passing through ¾ in. and 16 per cent. through ¼ in. The main point, therefore, seems to be that the gasification must be affected by the grading of the fuel, provided the producer is large enough. It does not often happen unless the installation has been built with due thought to this point, but provided the producer grate area is large enough a very high proportion of breeze can undoubtedly be burned with advantage to the undertaking, so releasing a corresponding or nearly corresponding proportion of better quality fuel for sale.

Question of Maintenance.

As to maintenance, it is probably more difficult to compare maintenance costs for different works than any other figure, because these costs are obtained under conditions which vary so infinitely; and unless one knows the whole circumstances it is most difficult to draw any conclusions from them. We have had during the last 10 years a number of papers presented to the Institution of Gas Engineers in which costs of maintenance have been quoted, but I think Mr. Blundell's figures are the best that have been laid before us; and I am sure we would all wish to congratulate him on these excellent figures. In doing this, however, I should like to say that I think he has been a little favoured in his coal, and I think there are gentlemen in this room who can quote figures which would rival Mr. Blundell's, but these people have not come into public with their figures. I know there are plants which have been working 10, 11, and even 12 years in which not a brick has been repaired or replaced, but there again coal has been the dominating factor. I should only like again to say how much we all appreciate Mr. Blundell's paper which provides so much food for thought.

Utilizing Coke Breeze.

Eng.-Capt. J. Fraser Shaw (Fuel Research Board): I will be as brief as I possibly can, but I think I have some information which will be of interest to you and which refers to the question of the utilization of breeze. The previous speaker has already mentioned the difficulty which is met with in general in dealing with breeze, and all the speakers have referred to it more or less. However, I think I can hold out some hope with regard to that point, because in Mr. Blundell's summary he left it out, probably because he thought it was hopeless. We at the Fuel Research Station have for the last six months been buying breeze from the South Metropolitan Gas Company to make our producer gas for our gas engine. We have used about 500 tons of breeze at the rate of about 16 lbs. per square foot of grate area per hour. Screen analysis of the breeze on a test which was run for 144 hours showed that there remained on ½ in. 23·7 per cent.; through ½ in. and on ¼ in. 21·7 per cent.; through ¼ in. and on ⅛ in. 24·2 per cent.; through ⅛ in. 30·4 per cent.—*i.e.*, through ⅛ in. there was 54·6 per cent. The ash content was in the region of 12 per cent. The capacity of the plant which we were dealing with was about 500,000 c.ft. per day, and it is simply a plain circular brick chamber 4 ft. 6 in. in diameter by 11 ft. 6 in. high. In fact, it is actually a Humphreys & Glasgow water gas plant which we have not used for water gas for some time. The credit for our success—because we have had success—is due to Mr. George Percival, the Works Superintendent at the Fuel Research Station, and the secret of the success is that we have introduced up and down running on this producer gas plant, just as if it were a water gas plant, the cycle being roughly 10 minutes up and 10 minutes down, charging about every 2½ hours.

The fuel bed is kept to a depth of 4 ft., but that depends on the size of the breeze. You will understand that when our breeze is shipped in 50-ton loads, and is put on to the bank, all the good stuff comes out at the front, and by the time we get to the bottom there is a good deal more than 50 per cent. or 60 per cent. dust which will pass through ¼ in., and we have to reduce the thickness of the fuel bed; but otherwise we do not seem to have any trouble. The actual pressure drop across the fuel bed is 9 in. air pressure. Another point which certainly does help us considerably is the fact that we have a space of 6 ft. 6 in. above the fuel bed and the centre line of the gas offtake. I will give you a few details. On the test of 144 hours that I mentioned we burned 16 lbs. per sq. ft. of grate area, and we were making 65 c.ft. of gas per lb. of breeze. The calorific value was steady at about 110. We clinkered once every 24 hours, and in actual clinkering we took out 4 cwt. of clinker and about 4 cwt. of ashes. That was about 16 per cent. of the fuel we used. The dust, which is so troublesome, did not trouble us to any great extent. We cleaned out the seal pot of the ordinary coke scrubber attached to the ordinary water gas plant every 24 hours, and took out 1½ cwt. of dust from the scrubber after six weeks. I imagine that most of it got there in the first day or so, and did not increase in quantity very much afterwards. When I say we cleaned out the scrubber, we took out a barrow load, just a hand truck load, of dust from the seal pot of the scrubber every day.

This test was done some two or three months ago, and since then we have improved rather, and there is no question that we could improve it still more. We are now burning 20 lbs. per sq. ft. of grate with a 24-hour cycle—*i.e.*, clinkering once every 24 hours. When we clinker once every 18 hours we burn nearly 22 lbs. per sq. ft. of grate area. The make of gas during these 24 hours is roughly as follows: For the first 6 hours we make 26,600 c.ft. per hour; for the next 8 hours we make 22,000 c.ft. per hour; and for the last 4 hours we make 19,000 c.ft. per hour. Then we clinker for about an hour, and we are away again inside the hour. Therefore, the total make works out at 480,000 c.ft. of gas per day. If we clinker every 18 hours we increase our gas make, because we cut out the last 4 hours, and then our make of gas is about 516,000 c.ft. per day. These are definite facts; and I shall be very pleased to give further details to anybody who is at all interested. The whole report will be published by the

Department later on in the summer. When I mentioned the fact that we bought our breeze from the South Metropolitan Gas Company you will, of course, realize that it is horizontal retort breeze that I am speaking about. As a matter of fact, I shall be very pleased indeed if anybody will send me, say, 20 tons of vertical retort breeze, because I shall be only too glad to put it through our producer and see what results we get. I do not doubt that we shall be just as successful in overcoming the difficulties of clinkering and rat holes with the vertical retort breeze as we have been with the horizontal retort breeze. This is some information which I hope will persuade somebody who has a larger producer than ourselves, hand fired, to try and prove that this work can be done on a producer which is bigger in diameter than 4 ft. 6 in.; and I should like somebody else who has got a mechanical grate producer to try it, because I honestly do think that there is every prospect of breeze being dealt with comfortably by this up and down running on any size of producer.

The Author's Reply.

Mr. Blundell: I do not propose to take up very much time, but I should like to refer to what Mr. Tarratt and one or two other speakers have mentioned—namely, the classification of coal. Undoubtedly Carlisle is in a peculiar position, inasmuch as the coals available at a reasonable price are practically almost all from the Cumberland coalfield, but I think that if Mr. Tarratt was to plot out on the well-known West's Steaming Curves his results at Newcastle and mine at Carlisle, he would find that they fall exactly on the same curve, so that if I have to take a compliment from Mr. Tarratt that I am doing very well, I should very much like to return that compliment to him, and say that he is doing quite as well as I am with the coals he has to use. I should like to thank everybody collectively if I may, in order not to take up time mentioning individual names, for the all-too-flattering remarks made not only about this paper but about previous work that I have been able to do on vertical retorts. There is just one question I should like to reply to, and that was the one raised by Mr. Tagg, who makes a novel but interesting suggestion that we should steam down to a lower calorific value and then raise the calorific value by removing the CO_2. I believe that in certain cases in Germany where gas is made from lignite and is supplied to domestic consumers, it is treated with some form of lime purification reducing the CO_2 content from 17-20 per cent. down to 3 or 4 per cent., with the result that the calorific value is raised from 4000 to 5000 calories per cub.m., which is equivalent to from 420 to 525 B.Th.U. per c.ft. To apply this method, or something like it, to the comparatively very small percentage of CO_2 found in English town's gas would certainly to my mind be a novelty. It would, however, be well to point out in the first place that it should not be assumed that gas of lower calorific value made by steaming in vertical retorts is necessarily characterized by a high CO_2 content. As long as the temperature of the charge within the retort is kept sufficiently high, there is no increase in the CO_2 of the gas made. Mr. Tagg gave me prior notice of this question, so that I was able to investigate what his suggestion would mean to Carlisle. Our gas contains about 4 per cent. of CO_2. We could steam down to 435 B.Th.U. without any increase in this percentage, and if the whole of the CO_2 were removed, it would bring our calorific value back to 453 B.Th.U., which is practically the value at which it is made for a declared value of 450 B.Th.U. The specific gravity of the gas would be reduced from 0·464 to 0·433, and the effect on the distribution system, on the basis of Pole's formula, would be to increase its capacity by 3·6 per cent.

The effect on the quantity of coke for sale would be to reduce the annual quantity by 1630 tons. The net coal cost per annum would be reduced by £760, which is equivalent to 0·307d. per 1000 c.ft. of gas made, so that, unless CO_2 purification could be carried out at a cost of 0·3d. per 1000 c.ft., there would be an increase in the cost of gas into holders. I have no information with regard to the cost of lime purification, and as far as I am aware, there are no published data upon which the cost of CO_2 removal could be calculated. The quantities at issue are small, but it does appear that this is a question to which the Research Committee of the Institution might devote their attention.

There is just one question I should like to refer to, and that is the one put by Mr. Richards about the price received for coke. The average price received for coke in Carlisle is 20s. per ton and the maximum selling price is 25s. per ton: and while I only sell in the local area 50 per cent. of the coke produced, I am always making contracts in competition with other coke at a much lower rate than 25s. per ton, and even then I cannot possibly get the business. (Of course, we do not want to dump coke in one another's areas in the North of England.) The remainder is sold for export.

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Gas Fire Flues and Ventilation

By C. A. MASTERMAN, M.A., F.I.C., and T. G. NOBLE, B.A.,

The Gas Light and Coke Company

INTRODUCTION.

The presence of a flue in conjunction with a gas fire is to be justified not as a gas fire prophylactic but as a normal and convenient method of ventilating any inhabited apartment. When a room is occupied in cold weather there is a tendency for the windows to be shut and the natural air change through the room is thereby considerably decreased. The presence of a flue—especially with a source of heat at the base—will accelerate movement of air through the room and so go far to prevent conditions becoming uncomfortable or unhealthy owing to air stagnation. If the source of heat is a coal fire, the presence of smoke and carbon monoxide in the products of combustion renders their complete removal a necessity, while the accumulation of soot in the flue requires that the chimney be of such dimensions as to allow a considerable margin in order to accommodate these deposits.

If the source of heat is a gas fire, no soot is deposited and the products of combustion are relatively unobjectionable (in the U.S.A. and elsewhere gas fires are often fitted without external flue). If the flue is to be used exclusively with gas fires it may therefore be sized precisely in relation to the extra degree of room ventilation required. In practice, with modern gas fires a flue of sufficient size to give even a very slight degree of room ventilation will be found easily adequate for the removal of all the products of combustion.

Considerable economy can result from the adoption of flues of small cross-sectional area, to be used in conjunction with gas fires and such flues are becoming increasingly popular in modern construction. Precise information as to their ventilating capabilities has, however, been absent.

The object of the present Paper has been to summarize into simple form the somewhat complex conditions which are involved. In general, chimneys will be found to induce a definite up-draught, often due to wind, apart from any specific source of heat at the base. Adverse wind or other conditions may sometimes, however, reverse the direction of flow. As such conditions are purely local, making generalizations impossible, the information given in this Paper assumes entirely still air conditions. Such conditions it is impossible to obtain on a flue connected to the outside air and for this reason the quantitative information presented in this Paper is derived from calculation—the correctness of which has been amply confirmed by experiment with flues mounted indoors. In the interests of compactness and simplicity, particulars of these tests and calculations together with other information of less general interest have been excluded from the Paper itself, but will be found in the Appendices.*

Most of the following Papers relate to Ventilation by Gas or Coal Fires. Other references occur in the text:

1st, 2nd, and 3rd Reports of the Joint Ventilation Research Committee of the Institution of Gas Engineers and Leeds University	Transactions of the Institution of Gas Engineers— 1914, p. 123; 1915, p. 56; 1916, p. 95
Dr. Margaret Fishenden	"House Heating"— H. F. & G. Witherby, 1925
Dr. Margaret Fishenden	"The Coal Fire"— Fuel Research Board Special Report No. 3. Department of Scientific and Industrial Research
Dr. Margaret Fishenden	"The Domestic Grate"— Fuel Research Board Technical Paper No. 13. Department of Scientific and Industrial Research
Coal Smoke Abatement Society (Dr. J. S. Owens)	The Lancet— May 10th, 1902, p. 1342; Feb. 20th, 1904, p. 5209; May 19th, 1906, p. 1413; Nov. 17th, 1906, p. 1361
17th Report of the Gas Investigation Committee of the Institution of Gas Engineers	Transactions of the Institution of Gas Engineers— 1926-27, p. 127
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H. Hartley	Gas Fire Development, 1913-15— Journal of Gas Lighting, Nov. 16th, 1915, Vol. CXXXII., p. 382
H. J. Yates	Report of the British Association for the Advancement of Science, 1915— Section B, p. 390; Engineering, 1915, 15, p. 403
H. Southern	Industrial Chimneys and Flues— Journal of Junior Institution of Engineers, June, 1930, p. 409 (containing a graphical comparison of some existing empirical equations)
Building Research Board	Report for 1927. p. 102. "Ventilation: An Experimental Comparison of the Efficiency of Flue and Wall Ventilator."
C. Véron	"Nouvelle Théorie du Tirage Naturel"— Société des Ingénieurs Civils, Oct. 10th, 1930
C. A. Masterman	"Combustion, Wind, and Flue Equipment. Trans. Inst. H. and V. Engs XXVIII., 1930.

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I. AIR ENTRY TO ROOM AND WIND EFFECTS.

Warm air rises because it is less dense than cold air. If this warm air is contained in a flue connected to a room, the warm air in rising up the flue draws other air into the room and so establishes an accelerated air movement. The performance of any flue is qualified by the ability of fresh air to find its way into the room, for if the room is sealed the air cannot continue to rise up the flue.

If the room to which the flue is connected is so nearly sealed as to affect the performance of a flue of small cross-sectional area, the provision of a larger flue will not result in appreciable increase in room ventilation. In order to determine the air movement which flues of various sizes and heights can induce, it is therefore assumed that access of air to the room itself is adequate.

It is often not realized how small are the forces in the flue which are responsible for the ventilation effect produced and how large relatively may be the forces due to adverse winds. A 1 ft. square column of air 10 ft. high weighs 0·76 lb. at 60° Fahr. and 0·52 lb. at 300° Fahr., so that the maximum potential pressure difference to which air movement will be due will be 0·24 lb. (Correction required for presence of diluted products of combustion may here be neglected.) A wind of 10 miles per hour can produce on a flat surface a static pressure in excess of this, and so may seriously disturb—or even reverse—the direction of movement of the flue gases. Stated slightly differently, the exit velocity of the flue gases from a domestic chimney will rarely exceed 10 miles an hour. The fact that adverse winds can create ventilation difficulties should therefore be no matter for surprise.

The cure for such difficulties is to be found in removing the adverse pressure difference between the top and the bottom of the flue, the cause of which is to be traced to the conversion of some part of the kinetic energy of the wind into a static pressure. If this conversion is only partial, the remaining kinetic energy or movement of the air can be used in a suitable special terminal to induce updraught in the flue. If, however, the flue terminal is on the windward side of the building in a posi-

* Appendices 1 and 5 are also given *in extenso* in this issue of the "JOURNAL."

tion where the wind is trapped and actual air movement is nearly absent, no special terminal can effect a cure. Another position must be sought for the termination of the flue, it may be a few feet distant only, in a zone where the air is moving and the static pressure is consequently less. The instinct to avoid exposed positions for the terminal is definitely unsound.

If poor ventilation or positive down draught is experienced on a flue having a large exit area the cause may be traced to downward syphoning of cold air or to a low exit velocity of the flue gases. Either of these may be corrected by fitting a small chimney pot or in some other manner restricting the area at the terminal.

II. THE PRODUCTS OF COMBUSTION AND THEIR REMOVAL.

The products of combustion from a normal 10-radiant gas fire and their maximum concentrations at the flue spigot if no extra flue is attached are approximately as follows:[1]

Products.	Volume per Hour (60° Fahr.).	Concentration (without Flue).
	C.Ft.	Per Cent.
Water vapour	45·0	3·0
Carbon dioxide	22·5	1·5
Sulphur dioxide	0·02	0·001
Carbon monoxide	0·045	0·003
Nitrogen peroxide	0·015	0·001

Owing to its pungent odour, sulphur dioxide is appreciable at the extreme dilution of 0·0003 per cent., at which concentration it is without immediate harmful effect, while at corresponding concentrations the associated gases are far below the limits at which they can exert appreciable physiological action.

While there can be no sound hygienic reason for demanding the complete removal from the room of all the products of combustion, such removal, in the absence of cross draughts in the room is so easily accomplished with modern gas fires that a 100 per cent. standard has become accepted.

The conventional type of independent modern gas fire is designed to be capable of removing all the products of combustion through the flue spigot with no additional flue attached. The excess air through the spigot per c.ft. of gas burnt is then as a rule less than 30 c.ft., representing, as will be seen, in normal conditions less than half an air change per hour. Since the information later presented shows the air movement up any normal chimney is several times this amount there need be no misgivings that the hot gases passing the spigot will fail to be extracted to the outside air by the draught established in the flue.

The inset type of gas fire designed to be fitted into an existing opening and having no canopy of its own is now becoming increasingly popular. Doubts have been expressed as to the capabilities of such fires to direct their products up the chimney. Tests in this connection (Appendix (1)) have shown that the behaviour of inset fires is much more reliable in this respect than had been supposed and that the controlling feature is the height rather than the projection of the canopy or lintel. Provided this height does not greatly exceed 2 ft. above floor level a flue which is capable of inducing physiologically acceptable ventilation will be found capable of removing all the products of combustion from the normal types of inset fire. (It is assumed that the fire is correctly mounted, the top of the radiants not projecting beyond the front edge of the canopy or lintel.)

The tradition of air contamination at one time associated with gas fire installations must now be discarded and the cause of such contamination if and when it does exist must be traced to the positive defect which is responsible and which can and must be corrected.

III. HEAT INPUT TO FLUE.

The greater the amount of heat passing to the flue the greater will be the ventilation effect produced, provided the flue temperature does not exceed about 500° Fahr., which is far above gas fire flue limits. The facts presented in this Paper will be available most conveniently if they are interpreted into particulars as to size of flue required for any given size of room to produce a given degree of ventilation. It is therefore essential to gauge the size of gas fire which should be fitted and the proportion of heat from the fire which will pass up the chimney. In order accurately to size the fire in relation to the size of room in which it is to be used it is necessary to take into account the degree of exposure of the room, type of construction, window area, &c. One radiant per 300 c.ft. of room space will usually be an under-statement of requirements, but may sometimes represent the situation, except in the smallest rooms where 200 c.ft. per radiant is taken for rooms of 1000 c.ft. capacity and 250 c.ft. per radiant for rooms of 1500 c.ft.

Of the heat produced by combustion of the gas, part will pass into the room and part will pass straight up the flue. As the room becomes warm, the air in the room becomes warm and much of this air will ultimately pass back to the fire and up the chimney. Thus, with a perfectly insulated room all the heat from the gas would ultimately pass up the chimney.

VENTILATION INDUCED BY VARYING HEAT INPUT TO VARIOUS SIZES OF FLUE.

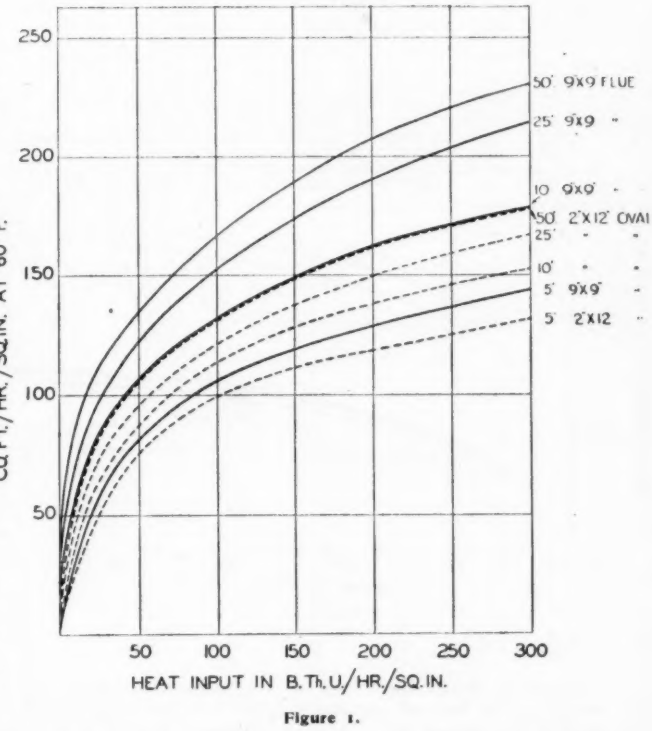


Figure 1.

In practice, heat losses take place through the walls, windows and ceilings, so 50 per cent. of the total heat of the gas will be taken as the sensible heat passing to the flue. This is probably under-stating the heat input to the flue when the room is warmed up, but over-stating it for the initial stages when the fire is first lighted. If the thermal efficiency of the gas fire is above normal a smaller proportion of the total heat will pass up the flue under practical conditions while a smaller fire will become adequate for the same size of room. Figure 1 indicates the ventilation produced with varying heat input to the flue, both expressed per square inch of cross section of flue for flues 9 in. by 9 in. and 12 in. by 2 in., with external air temperature 60° Fahr. In colder weather increased ventilation effect is obtained.

IV. FLUE DIMENSIONS AND VENTILATION.

[Appendices 3 and 4 are not given in this issue of the "JOURNAL."]

If the flue is short, increasing the height will increase the degree of induced ventilation, but to this effect there

[1] Trans. Inst. Gas Eng. No. 41, Nov., 1931.
Trans. Inst. Gas Eng. No. 36. Nov., 1931.

is a limit beyond which little advantage is gained by adding further to the height (see Appendix (4)), unless by so doing troublesome wind effects can be avoided or the effect of restrictions in the flue can be overcome. Excessive height if the flue is very exposed may even lead to condensation troubles which should normally be absent in flues connected to gas fires (see Appendix (3)).

The greater the cross sectional area of the flue the greater is the degree of induced ventilation for the same heat input, but the effect of large cross-sectional area is often prejudiced by the presence of restrictions which have been allowed to be present whether by accident or design. On small flues serious obstruction may often result from the presence of extruded mortar from the joints on the inside surface (the area of a 5 in. by 5 in. flue may be diminished to the extent of about 20 per cent. by a $\frac{1}{4}$ in. web of mortar while on the 12 in. by 2 in. flue the decrease would be nearly 30 per cent.). Provided the area of the flue is adequate the shape of the cross section is relatively unimportant, but flattening to a cross dimension of less than 2 in. will usually be inadvisable.

Local reductions in flue area may have considerable effect upon induced ventilation. Such reduction may be represented by the flue spigot of the fire itself if this is sealed to the flue, it may be in the flue, or it may be at the flue terminal or chimney pot.

VENTILATION INDUCED UNDER VARIOUS CONDITIONS BY 10 RADIANT FIRE WITH AUXILIARY FLUE OPENING

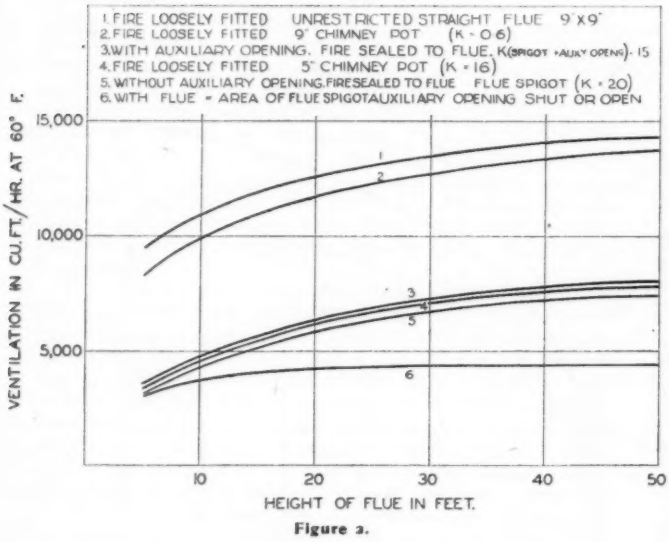

1. FIRE LOOSELY FITTED UNRESTRICTED STRAIGHT FLUE 9"X9"
2. FIRE LOOSELY FITTED 9" CHIMNEY POT (K = 0·6)
3. WITH AUXILIARY OPENING. FIRE SEALED TO FLUE. K(SPIGOT + AUXY OPENG) · 15
4. FIRE LOOSELY FITTED 5" CHIMNEY POT (K = 16)
5. WITHOUT AUXILIARY OPENING. FIRE SEALED TO FLUE FLUE SPIGOT (K = 20)
6. WITH FLUE = AREA OF FLUE SPIGOT AUXILIARY OPENING SHUT OR OPEN
VENTILATION IN CU. FT./HR. AT 60° F.
15,000
10,000
5,000
1
2
3
4
5
6
10
20
30
40
50
HEIGHT OF FLUE IN FEET.

Figure 2.

Figure 2 shows the effect of a number of different restrictions in flues of various heights used in conjunction with a 10-radiant fire. A 9 in. chimney pot on a 9 in. by 9 in. flue naturally reduces the ventilation very little, but if the fire is of the independent type and is sealed into place instead of being fitted loosely the ventilation is reduced by about half. A 5 in. chimney pot (or equivalent terminal) has similar effect. Note that the various restrictions referred to will have decreasing effect as the cross sectional area of the flue itself is reduced. On the basis previously referred to, a 10-radiant fire will not be fitted in a room exceeding about 3000 c.ft. capacity so that the induced ventilation produced by a 30 ft. flue in the cases shown will range from over 4 air changes per hour down to about $1\frac{1}{2}$.

Change in the direction of the flow of flue gases has an effect on ventilation similar to but usually less than that of a reduction of area, the effect being the greater the more abrupt the bend. Thus an abrupt change of direction through 90° is equivalent to a local restriction of area 0·7 on a straight flue of area 1, while changing direction by two successive turns of 45° is equivalent to a local restriction of area 0·8. The effect may seem small, but to obtain the same ventilation as with an unrestricted flue requires in the former case a flue $2\frac{1}{2}$ times as high and in the latter one $1\frac{1}{2}$ times as high. Note that the same results follow if the change in direction is due not to a bend or elbow but to the presence of a flat surface in near proximity to the open end of the flue. If the area for lateral exit of the flue gases corresponds to the area of the flue itself such an arrangement corresponds in effect to an abrupt elbow at 90°. Such cases sometimes occur both in connection with the flue spigot and chimney base, and in the case of some terminals.

There can be no final conclusion stated as to the correct degree of ventilation required to maintain hygienic conditions. Ventilation in any room should be at a maximum compatible with adequate heating and the absence of uncomfortable draughts, and these will greatly depend upon local conditions, such as position of window, &c. Over 5 air changes per hour may easily lead to discomfort, while under 2 air changes will usually be inadequate in an occupied room. In the absence of a flue less than half this suggested minimum may exist if doors and windows are shut. The flue should therefore be capable of inducing between 2 and 4 air changes per hour if ideal conditions are to be obtained.

The fitting of a ventilator into the flue just below ceiling level has sometimes been advocated as a desirable auxiliary, one result of which will be to diminish draughts at floor level. If the ventilator is of sufficient size to be of use, the result will be to diminish the effective height of the flue, so that if the height above the vent is very short the decrease in induced ventilation may be considerable.

V. CONCLUSIONS.

[Appendix 4 is not given in this issue of the "JOURNAL."]

Flues of quite small size will be found capable, in conjunction with gas fires, of producing an appreciable and often desirable ventilation to a room. Any such flue is much more than adequate for the complete removal of the products of combustion of the fire itself. The greater the cross-sectional area of the flue, the greater the heat input to the flue, or the greater (within limits) the height of the flue the greater will be the ventilation effect produced, these three main factors being in this order of importance (Figure 8, Appendix (4)).

Restrictions in the flue will reduce the degree of ventilation. Such restrictions may be due to careless finish of the inside surface of the flue, abrupt changes of direction of the flue gas path or local reductions in area. Figure 3 shows the induced ventilation produced with various unrestricted flues of various heights with various fires in the absence of wind. (For method of determination see Appendix (4).) If restrictions of any sort are present the heights shown are inadequate.

If the height of restricted flue required to produce a given degree of ventilation is to be determined, the equivalent height of unrestricted flue derived from the curve must be multiplied by (1 + the sum of the restriction factors k).

Thus actual height required

$$= \text{unrestricted flue height} \times (1 + k_1 + k_2 + k_3 + \text{etc.})$$

If the degree of ventilation produced by a given height of restricted flue is to be determined this height must be divided by (1 + the sum of the restriction factors k), and the resulting equivalent height of unrestricted flue must be used with the appropriate curve.

Equivalent unrestricted flue height

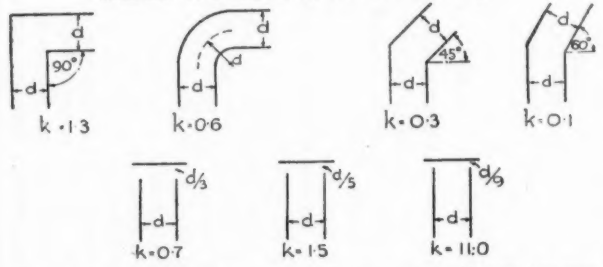
$$= \frac{\text{Actual height}}{1 + k_1 + k_2 + k_3 \text{ etc.}}$$

The values for k for various restrictions are shown in Figure 3 (see also Appendix (4)). Note that the effects upon ventilation of quite minor restrictions which are negligible with flues of normal height may be pronounced in the case of very short flues.

Table I. shows the minimum cross-sectional area of square flue which is required under various practical conditions to produce induced ventilation of 2 and 4 air changes per hour in the absence of wind, assuming that 50 per cent. of the total heat from the fire ultimately passes up the flue as sensible heat. The basis of the method of determining these dimensions is

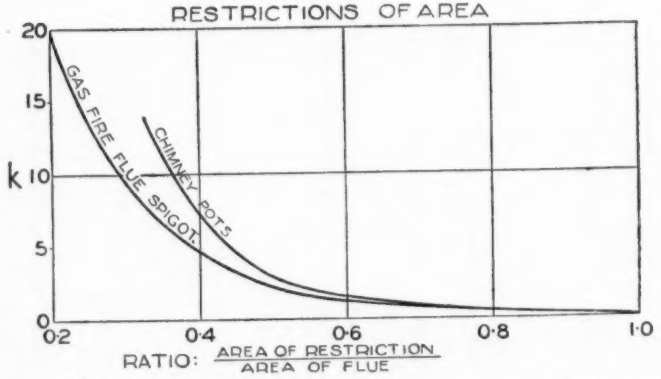
VALUES FOR RESTRICTION FACTOR k.

CHANGE OF DIRECTION (FULL AREA OF FLUE)



RUN OF HORIZONTAL FLUE PER 10 MEAN DIAMETERS LENGTH
k·0·5.

RESTRICTIONS OF AREA



NOTE : NORMAL GAS FIRE FLUE SPIGOT AREA = 2·5 SQ INS. PER RADIANT.

INDUCED
VENTILATION DUE TO STRAIGHT UNRESTRICTED FLUES
WITH VARIOUS SIZE FIRES.

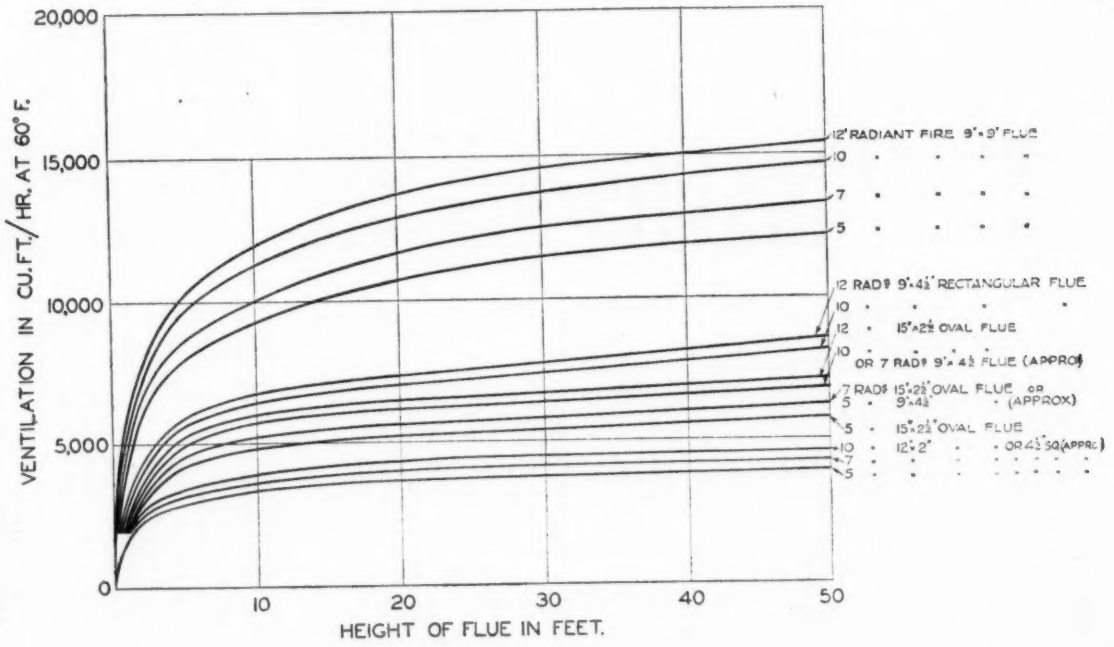


FIGURE 3.

TABLE I.—*Cross-Sectional Area of Flue Required in Square Inches for Loosely Fitted Fire.*

Capacity of room in c.ft.		1000	1500	2100	2400	2700	3000	
Size of fire (in number of radiants)		5	6	7	8	9	10	5
Air Changes per Hour.	Height in Feet.							
A. Straight unrestricted flue.								
2	15	11	17	24	26	29	31	42
2	30	10	15	22	24	27	29	38
4	15	25	38	54	62	68	74	100
4	30	23	35	48	54	59	67	82
B. Flue with restriction K = 0·6, *e.g.*, short rake 45°, single bend, or terminal area 4/5 that of flue itself.								
2	15	12	19	26	29	32	35	46
2	30	11	16	23	26	28	31	41
4	15	28	43	62	68	77	83	*
4	30	24	39	53	59	65	72	91
C. Flue with restriction K = 1·3, *e.g.*, abrupt 90° elbow, or terminal area 7/10 that of flue itself.								
2	15	13	20	28	31	35	39	50
2	30	12	17	24	27	29	32	43
4	15	31	47	69	73	86	92	*
4	30	25	42	57	63	70	76	100
D. Flue with restriction K = 3·0, *e.g.*, two abrupt 90° elbows, or terminal area 1/2 that of flue itself.								
2	15	15	23	31	36	41	46	60
2	30	12	19	27	30	34	37	50
4	15	37	55	82	87	88	*	*
4	30	28	48	66	74	82	86	*
E. Flue with restriction K = 10, *e.g.*, terminal or flue obstruction reducing area locally to 1/3 that of flue itself.								
2	15	23	36	43	60	67	73	100
2	30	17	27	38	43	49	55	70
4	15	55	88	*	*	*	*	*
4	30	39	65	96	*	*	*	*

given in Appendix (4). In all cases it is assumed that the fire is loosely fitted or is of the inset type so that there is free access for air at the base of the flue. If the section of the flue is very flattened in shape, slightly greater area must be allowed to compensate for the increased resistance. If, as may often be the case, the size of fire actually used is greater than that shown, an increased ventilation will result; to obtain the 2 or 4 air changes per hour a decreased area would suffice. The relative ease with which air movement of 6000 c.ft. per hour (the last column of Table I.) can be obtained even with the 5-radiant fire is of interest.

The values shown thus, *, exceed 100 square inches and are clearly impractical. In larger rooms the amount of incidental ventilation from windows, doors, &c., renders a degree of induced ventilation exceeding about 2 air changes per hour quite unnecessary.

Table II. shows the minimum cross-sectional area of square flue under the same conditions as in Table I. except that the fire or flue spigot is sealed to the base of the flue. Although 2 air changes per hour can be obtained without undue increase in the area of flue, as compared to unsealed conditions the restriction created by the gas fire flue spigot does impose a definite upper limit to the degree of ventilation which is possible in practice. In practically no case can 4 air changes per hour be obtained with these heights of flue however much the flue area itself is increased.

TABLE II.—*Cross-Sectional Area of Flue required in Square Inches with Fire Sealed to Flue.*

Capacity of room in c.ft.		1000	1500	2100	2400	2700	3000
Size of fire (in number of radiants)		5	6	7	8	9	10
Air Changes per Hour.	Height in Feet.						
A. Straight unrestricted flue.							
2	15	11	18	26	30	33	37
2	30	10	15	24	27	29	30
B. Flue with restriction K = 0·6, *e.g.*, short rake 45°, single bend, or terminal area 4/5 that of flue itself.							
2	15	12	20	28	33	36	41
2	30	11	16	25	29	30	32
C. Flue with restriction K = 1·3, *e.g.*, abrupt 90° elbow, or terminal area 7/10 that of flue itself.							
2	15	13	21	30	35	39	45
2	30	12	17	26	30	31	33

APPENDIX (1).

TESTS ON CANOPY LIMITS FOR INSET FIRES.

In the absence of any precise information special canopies have often been fitted in conjunction with inset fires in order to guarantee the complete removal of the products of combustion. In order to determine whether such special fittings are essential, tests have been made to discover the critical limits of size and position of the canopy required with four representative types of fire.

The fires were in turn fitted into a fire-place to which was attached a 9 in. by 9 in. aluminium flue, the height of which could be varied, and a rectangular canopy adjustable in a horizontal or vertical direction. The shape was chosen as being the least favourable likely to be met with in practice.

Two methods of testing for escape of products from around the canopy were employed, one being the usual Lancet Test (carbon tetrachloride and ammonia) and the other an optical method. The latter consisted in throwing a shadow of the fire on to a screen, the illumination being from a projector placed at the side of the fire with the axis of the beam parallel to the front of the fire. The movement of the hot gases was traceable by the shadows cast on the screen. It was anticipated that difficulty would be experienced in distinguishing between hot diluted products of combustion, and hot convection currents of air rising from the heated surfaces. In fact the difficulty was much less than might have been expected. There were two kinds of shadow; one a thin wisp travelling upwards close to the heated surface (*e.g.*, the front of the canopy) and obviously due to surface convection, the other a voluminous shadowy effect, turbulent in nature, which came directly from the radiants and from beneath the canopy. This was found, by the Lancet Test, to be due to the diluted products. Whenever there was any doubt the Lancet Test was employed to check the shadow test. As an additional precaution a water cooled canopy was employed for some experiments to prevent interference by the convection effect. When this was used the thin shadows disappeared, and the fact that the other shadow was due to hot products was confirmed by the condensation of water on the cold surface when the shadow test indicated that some of the products were coming into the room. This precaution was soon judged unnecessary and the simple sheet metal canopy was therefore employed for the majority of the experiments.

The fires used for test were as follows:

A. Nine vertical radiants, fire back concave to room.
B. Nine radiants backwardly curved, convex to room.
C. Nine straight inclined radiants with "cokette" layer above.
D. Ten small straight inclined radiants in unit designed for use in front of solid fuel fire.

In the first series of test to which Table I. refers, the flue under which the fires were mounted represented the worst possible case and was restricted so that it only just removed the products of combustion of an independent type fire to which it was first connected.

By "height of canopy" is meant the height of the lower front edge of the canopy or lintel from the level of the floor or lowest point on the inset fire. By "size of canopy" is meant the distance the lower front edge of the canopy projects beyond the fire surround against which the edge of the inset fire is normally mounted.

The results indicate that, even in these extremely adverse conditions, when properly arranged all these fires are capable of passing all their products of combustion up the flue.

The fire Type A in which the plane of the radiants is

APPENDIX (1)—TABLE I.—*Limits of Canopy Size (Inadequate Flue).*

Fire.	Size of Canopy.	Height of Canopy.	Result of Test.
1	2	3	4
A.	In. 0	Any height	Passes without canopy in all positions.
B.	In. 0	Any height	Fails.
	1	Ft. In. 1 4	Just passed.
	1	1 6	Passed.
	1	1 9	Just failed.
	3	1 10	,, ,,
	4	1 10	Passed.
	6	1 10½	,,
C.	In. 0	Any height	Fails.
	1	,, ,,	,,
	1½	Ft. In. 1 3	Passes.
	2	1 6	,,
	3	1 7½	,,
	6	1 8	,,
D.	In. 0	Ft. In. 1 3½	Passes.
	1	1 4	Just fails.
	4	1 5	Fails.
	5	1 4½	Passes.
	6	1 5	,,

behind the plane of the fire surround clearly requires no additional canopy in any normal circumstances.

The fire Type D is only intended to be used where the flue is adequate for the solid fuel fire to which it is an auxiliary so that such adverse conditions as those indicated cannot arise.

The removal of products of combustion from fires of Types B and C clearly depends more upon the height than upon the projection of the canopy. Further tests were carried out with a seven radiant Fire C as representing the less satisfactory fire of the two from the clearance point of view (Table II.), below.

APPENDIX (1)—TABLE II.—*Limits of Canopy Size (Fire C) Short Flues.*

Size of Canopy (Projection).	Height of Canopy.	Size of Flue. (Normally 9 In. by 9 In., but restricted as shown.)	Area in Sq. In.	Height of Flue.	Result of Test.
1	2	3	4	5	6
In.	Ft. In.			Ft.	
0	1 6	9 in. by 9 in.	81	2	Passed.
0	,,	9 in. by 6 in.	54	,,	,,
0	,,	6 in. by 6 in.	36	,,	Failed.
0	,,	9 in. diam. circular	64	,,	Passed
0	,,	7 in. diam. circular	38½	,,	Failed.
7	2 0	9 in. by 3 in.	27	3	Passed.
6	,,	9 in. by 3 in.	27	,,	Failed.
1	,,	7 in. diam. circular	38½	,,	Passed.
0	,,	7 in. diam. circular	38½	,,	Failed.
0	,,	9 in. diam. circular	64	,,	Passed.

The degree of ventilation represented by the limiting cases without a projecting canopy represents only about 100 c.ft. of air per c.ft. of gas burnt. This is considerably under 2 air changes per hour on the basis referred to in the body of this report.

In general, provided the height of the canopy or lintel does not much exceed 2 ft., no projection of canopy appears to be required to remove the products of combustion under normal conditions. If, however, the front edge of the radiants extends more than 5 in. beyond the plane of the surround (the limit in these cases) the canopy must be extended beyond that plane by the same amount. An alternative rule so far as the fires tested (excluding D) are concerned is that the plane of the front edge of the canopy or lintel should not be behind the tops of the radiants and should not be much more than 12 in. above them.

It will be realized that, as with coal fires, adverse wind conditions or cross-draughts in the room may occasionally causes traces of the products of combustion to pass into the room. Such occasional traces of the products from gas fires will be quite inappreciable in contrast with the intolerable conditions created by a " smoky " coal fire.

APPENDIX (5).

GENERAL DIMENSIONS OF FLUE PIPES.

SYMBOLS.

- A = Cross-sectional area of flue in square feet.
- B = Thickness of flue wall in feet.
- G = Weight of 1 c.ft. of air in lbs. at T° Fahr. absolute.
- G_a = Weight of 1 c.ft. of flue gases in lbs. at T + t° Fahr. absolute.
- H = Height of flue in feet.
- K = Coefficient of conductivity of flue wall (B.Th.U. per sq. ft. per foot per hour per ° Fahr.).
- Mx = Total heat input to flue per second in B.Th.U.
- My = Effective heat through flue per second in B.Th.U.
- R = Total resistance of flue installation in lbs. per sq. ft.
- T = Temperature of external air in ° Fahr. absolute = temperature of external air in ° Fahr. + 459·4.
- S = Total internal surface of flue in sq. ft.
- U = Velocity of flue gases in feet per second.
- W = Weight of flue gases passed per second in lbs.
- d = Width of flue in inches.
- g = Gravitational constant = 32·2.
- k = Restriction factor of fittings, &c.
- m = Hydraulic mean depth = $\frac{\text{area}}{\text{perimeter}}$.
- q = Heat input to flue in B.Th.U. per c.ft. of gas.
- t = Mean temperature rise of flue gas in ° Fahr.
- x, y = See Mx, My.
- γ = Kinematic viscosity in ft./lb./second units.
- ζ = Coefficient of friction.

It has seemed desirable to carry the information contained in Appendix (4) a stage further and to present a series of curves and some simple equations relating to flue pipes generally without special regard to gas fire flues.

An appliance will deliver its products of combustion to the secondary flue at the baffler in definite quantity and at a definite temperature depending upon the gas rate, the CO_2 concentration, and on the thermal efficiency of the appliance.

APPENDIX (5)—TABLE I.—*Volume, Weight, and Temperature of Flue Gases.*

Per Cent. CO_2.	Per C.Ft. of Gas Burnt. (Gross C.V., 500.)		Heat in Flue per C.Ft. Gas Burnt.			
	Vol. (60° Fahr.) of Products in C.Ft.*	Weight of Products in Lbs.*	25 B.Th.U.	30 B.Th.U.	40 B.Th.U.	50 B.Th.U.
			Temperature Rise of Flue Gases in ° Fahr.			
1	2	3	4	5	6	7
10	6·0	0·44	227	271	364	454
9	6·6	0·49	204	245	327	408
8	7·2	0·53	189	227	302	378
7	8·1	0·60	167	200	267	334
6	9·3	0·69	145	174	232	290
5	11·0	0·81	123	148	197	248
4	13·5	1·00	100	120	160	200
3	17·7	1·35	74	89	119	148
2	26·0	1·92	52	62	83	104
1	51·0	3·77	27	32	42	53
0·5	101·0	7·40	14	16	22	27
0·1	502·0	37·1	3	3	4	5

* Assuming no condensation takes place.

If W the weight of products to be removed per second and My the effective heat input to the flue per second are both known the flue dimensions required may be determined by using the equations in Appendix (4). If the CO_2 concentration and flue temperature are known, or if either is known together with the heat input to the flue derived from the thermal efficiency of the appliance, the values of W and My can be easily calculated in relation to the gas rate.

The weight of gases to be removed per c.ft. of gas burnt will depend upon the actual CO_2 concentration in the flue, the value of which will be lower than that determined in the normal way at 60° Fahr. by an amount depending upon the water vapour present. If no condensation takes place at 9 per cent. CO_2 concentration the actual CO_2 concentration in the flue gases will be 0·85 × determined concentration. Although this correction factor approaches unity as the CO_2 concentration decreases a standard figure considerably simplifies the subsequent equations, and the above figure will be adopted even though it allows an appreciable margin of capacity

at lower CO_2 concentrations. Assuming as in Table I. of this Appendix that 1 c.ft. of gas produces 0·5 c.ft. of CO_2 and 1 c.ft. of water vapour at 60° Fahr., the volume of products to be removed per c.ft. of gas burnt will be

$$\frac{0{\cdot}5 \times 100}{0{\cdot}85 \times CO_2\,\%} \text{ c.ft.}$$

If the weight per c.ft. at 60° Fahr. is 0·074 lb. the weight to be moved per second:

$$W = \frac{\text{Gas rate}}{3600} \times \frac{0{\cdot}5 \times 100}{0{\cdot}85 \times CO_2\,\%} \times 0{\cdot}074$$

$$= \frac{\text{Gas rate}}{826 \times CO_2\,\%}$$

Assuming specific heat in B.Th.U. per lb. per ° Fahr. = 0·25 the heat input to the flue per second:

$$My = tW \times 0{\cdot}25$$

$$= 0{\cdot}25t \left(\frac{\text{Gas rate}}{826 \times CO_2\,\%}\right)$$

Substituting these values in Equation (7) of Appendix (4),

$$\frac{2gHA^2}{1 + \frac{\zeta S}{A}} = \left(\frac{\text{Gas rate}}{826 \times CO_2\,\%}\right)^2 \left(\frac{23{,}100}{0{\cdot}25t} + 350 + 1{\cdot}32 \times 0{\cdot}25t\right)$$

For fairly smooth round flues

$$\frac{\zeta S}{A} = \frac{0{\cdot}03H}{\sqrt{A}}$$

$$\text{Hence } \frac{1}{H} = \frac{826^2 \times 64{\cdot}4A^2\,CO_2\,\%^2}{\text{Gas rate}^2 \left(\frac{92{,}400}{t} + 350 + 0{\cdot}33t\right)} - \frac{0{\cdot}03}{\sqrt{A}}$$

For A substituting $\frac{d^2\,\pi}{4 \times 144}$ where d = diameter of flue in inches and introducing the restriction factor k

$$\frac{1 + k}{H} = \frac{4000d^4\,CO_2\,\%^2}{\text{Gas rate}^2 \left(\frac{2{\cdot}8 \times 10^5}{t} + 1060 + t\right)} - \frac{1}{2{\cdot}46d} \quad \text{.....(A)}$$

$$\text{or Gas rate} = \sqrt{\frac{4000d^4\,CO_2\,\%^2}{\left(\frac{2{\cdot}8 \times 10^5}{t} + 1060 + t\right)\left(\frac{1 + k}{H} + \frac{1}{2{\cdot}46d}\right)}}$$

If the sensible heat in the flue per c.ft. of gas = q B.Th.U.

$$My = \frac{\text{Gas rate} \times q}{3600} = 0{\cdot}25t \left(\frac{\text{Gas rate}}{826 \times CO_2\,\%}\right) \text{(above)}$$

$$\therefore t = 1{\cdot}27 \times q \times CO_2\,\%.$$

Substituting in Equation (A) leads to Equation (B)

$$\frac{1 + k}{H} = \frac{3150d^4\,CO_2\,\%^2}{\text{Gas rate}^2 \left(\frac{1{\cdot}72 \times 10^5}{q \times CO_2\,\%} + 836 + q \times CO_2\,\%\right)} - \frac{1}{2{\cdot}46d}$$

$$\text{or Gas rate} = \sqrt{\frac{3150d^4\,CO_2\,\%^2}{\left(\frac{1{\cdot}72 \times 10^5}{q \times CO_2\,\%} + 836 + q \times CO_2\,\%\right)\left(\frac{1 + k}{H} + \frac{1}{2{\cdot}46d}\right)}}$$

Owing to radiation and other losses a proportion only of the sensible heat not used in the appliance will be effective in the flue, and caution is required if this value of q is to be derived from the thermal efficiency figure.

Equations (A) and (B) are convenient for the determination of height or appropriate gas rate if the mean flue gas temperature or the effective sensible heat in the flues respectively are known. (See Example at end.) The determination of the appropriate diameter which will be required more usually in practice is less straightforward owing to the double exponent qualifying this factor in both equations. Figure 1 of this Appendix has therefore been calculated from Equation (A) for the quick determination of the correct diameter of flue to be used under any conditions. (For Gas Fire Flues see Section V. of this Paper.)

Curves for Determining Flue Diameter (Figure 1 of this Appendix).

Size of Flue.—The height of the proposed flue is found on the scale on the left-hand side of the figure. The gas rate is found on the upper set of scales if the CO_2 is above 9 per cent. or if the combustion is incomplete (*e.g.*, furnace), and on the lower set of scales if the CO_2 is between 9 per cent. and 4 per cent. The diameter so determined is a minimum and the correct diameter of flue to be used is the greater of the two sizes between the curves of which lies the intersection of the height line and the gas rate line.

Height.—If the flue equipment used is other than any of the varieties shown the actual height must be corrected to an equivalent unrestricted height to be read on the right-hand of the set of scales. This correction is made by dividing the actual height by 1 + constants representing the various restrictions in the flue.

$$\text{Equivalent height} = \frac{\text{Actual height}}{1 + k_1 + k_2, \text{ \&c.}}$$

Terminals	$k = 0{\cdot}2 - 1{\cdot}5$ (Use 0·4 unless known to be high resistance)		
Bafflers	$k = 0{\cdot}4$	45° Elbow	$k = 0{\cdot}3$
90° **Bend**	$k = 0{\cdot}6$	90° Elbow	$k = 1{\cdot}3$

Horizontal flue per 2 diameters length $k = 0{\cdot}1$.

Note that if a baffler is used the flue below and the flue above the baffler must be treated as two independent systems (0·4 for the baffler itself must appear in the correction factor for each system). For the flue below the baffler, or if no baffler is used, the value of k for the appliance is required, but generally will be unknown. In its absence the size of flue determined will be such as to give the same CO_2 per cent. (and flue gas temperature) as is obtained from the same appliance before this flue is added.

CO_2 Concentration.—The less the CO_2 concentration in the flue gases the greater the weight of flue gases to be removed per cubic foot of gas burnt. Hence, the scale used must never represent a higher CO_2 concentration than is actually anticipated. Where greater precision is required, or where the CO_2 is below 4 per cent., the actual gas rate must be modified to an equivalent figure on one of the existing scales.

If the CO_2 is between 9 per cent. and 4 per cent. the actual gas rate is to be divided by the actual CO_2 per cent. and multiplied by 9, and this corrected rate used on the upper scale.

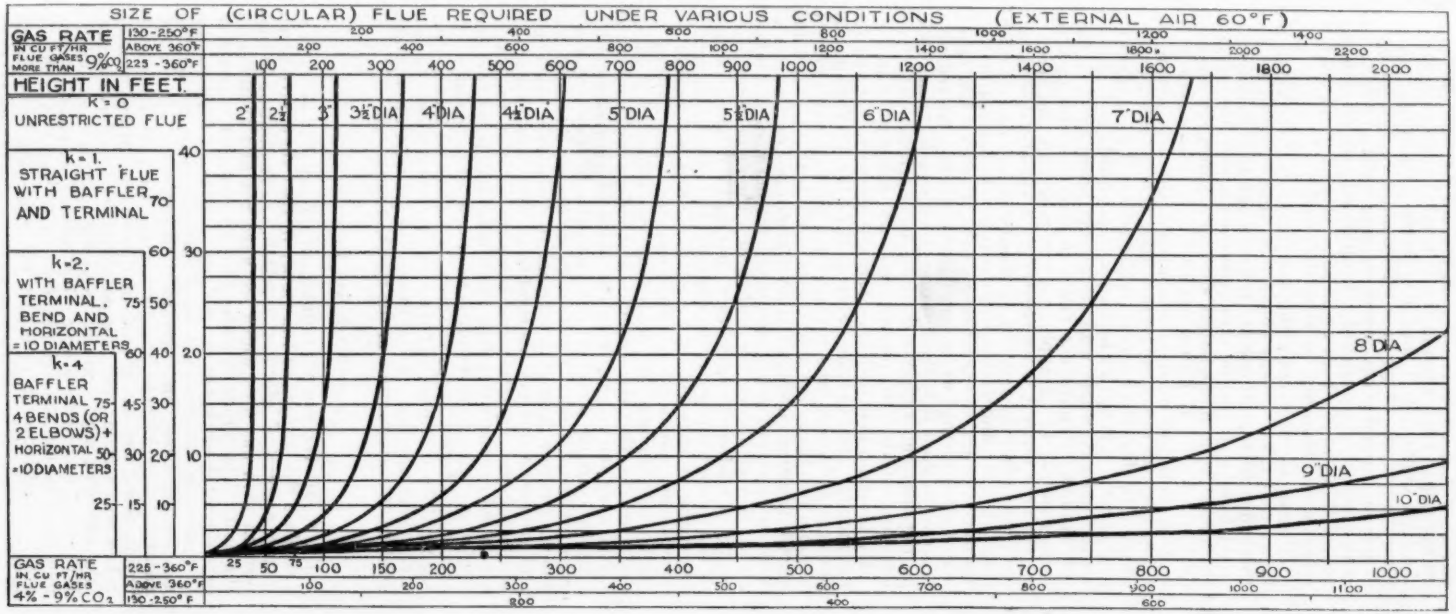
If the CO_2 is below 4 per cent. the actual gas rate is to be divided by the actual CO_2 per cent. and multiplied by 4, and this corrected rate used on the lower scale.

The lower CO_2 scale for gas rate has been re-corrected for the water vapour effect referred to earlier; the upper scale requires no re-correction.

If owing to different composition of gas the CO_2 production per cubic foot of gas is less than 0·5 c.ft. the gas rate scales in Figure 1 of this Appendix will determine flue dimensions giving some margin over minimum requirements. If the CO_2 production is more than 0·5 c.ft. the gas rate values shown on the scales require to be divided before use by twice the value in cubic feet of the CO_2 produced per cubic foot of gas.

Temperature.—Three scales of flue gas temperatures at base of flue are given in each CO_2 scale for gas rate, the 225° Fahr. to 360° Fahr. probably being the one usually applicable. If the temperature is below 130° Fahr. (70° Fahr. rise), but above 86° Fahr. (26° Fahr. rise) the main scale 225° Fahr.-360° Fahr. is to be used, but the gas rate values shown are to be halved.

Equations (A) and (B) embody no correction for heat losses, nor is accurate general correction possible. On the temperature scales corrections have been made



APPENDIX (5). FIGURE 1.—Size of (Circular) Flue required under various conditions (External Air 60° Fahr.).

assuming ⅓ the total heat is lost from the flue when the temperature at the base is 360° Fahr., ⅓ at 225° Fahr., ¼ at 130° Fahr., and ⅛ at 86° Fahr. These allowances will provide ample margin for practical conditions.

Note that if the heat input to the flue and not the flue gas temperature is known the temperature rise is given by 0·92 × CO_2 per cent. × B.Th.U. sensible heat input to flue per cubic foot of gas.

Wind.—Note that the flue dimensions derived from the curves are minimum values and will allow of no margin for the effect of adverse winds. If downdraught is anticipated a taller (or wider) flue will be of assistance, remembering that every additional 10 ft. of flue at 200° Fahr. above external air temperature, or 6 ft. at 400° Fahr., (external air temperature 60° Fahr.) represents an additional exit pressure to the flue gases of about 0·2 lb. per sq. ft., equivalent to the maximum static pressure a wind of 7 m.p.h. is capable of producing.

If for special reasons the appliance is connected directly to the flue, a height of flue additional to minimum requirements as calculated will produce excessive draught. A damper must then be fitted which can be withdrawn if adverse wind conditions prevail. Assuming the damper can be completely withdrawn, Figure 8, of Section V. of this Paper, shows the range of damper setting required to be:

$$\frac{\text{Area with damper open}}{\text{Area with damper shut}} = \frac{\text{Actual height of flue}}{\text{Correct minimum height}}$$

unless this ratio exceeds 2, when the relation becomes approximately

$$\left(\frac{\text{Area with damper open}}{\text{Area with damper shut}}\right)^2 = \frac{\text{Actual height}}{\text{Correct height}}$$

[Example of use of Equation B.

To find the correct gas rate for a boiler directly connected to a 6 in. flue 40 ft high having in its length 2 90° bends ($k = 1{\cdot}2$), 8 ft. horizontal flue ($k = 0{\cdot}8$), and a normal terminal ($k = 0{\cdot}4$).

The CO_2 per cent without flue is 9 per cent. and the thermal efficiency 75 per cent., both of which are to remain unaffected. Assuming that of the balance of sensible heat 75 B.Th.U. per c.ft. of gas only 50 B.Th.U. is effective in the flue = q.

Using Equation (B), alternative form

$$\text{Gas rate} = \sqrt{\frac{3150 \times 6^4 \times 9^2}{\left(\frac{1{\cdot}72 \times 10^5}{50 \times 9} + 836 + 0{\cdot}50 \times 9\right)\left(1 + \frac{2{\cdot}4}{40} + \frac{1}{2{\cdot}46 \times 6}\right)}}$$

$$= \sqrt{\frac{3{\cdot}3 \times 10^8}{1669\,(0{\cdot}085 + 0{\cdot}0677)}}$$

$$= \sqrt{1{\cdot}295 \times 10^5}$$

= 1138 c ft. per hour.

If some balance of pressure is required to offset possible downdraught the gas rate may be reduced to, say, 1000 c.ft. per hour for which (by working backwards) it can be determined that 26·1 ft. of flue would be sufficient. Thus there is 14 ft. at about 400° Fahr. or 0·4 lb. per sq.ft. available to offset wind effects.

In the absence of wind a damper must be used, of which the restriction factor kd is given by

$$\frac{40}{26} = \frac{3{\cdot}4 + kd}{3{\cdot}4}$$

or kd = 1·8, which from Figure 3, Section V., represents a restricted passage at the damper in area 0·6 that of the full area of the flue.]

DISCUSSION.

The PRESIDENT: I need hardly point out to you the very great value of the paper which has just been introduced by Mr. Masterman. It was originally intended that it should have been placed before you at the Autumn Research Meeting last year, but at that time it was not quite ready. I felt, however, that its importance and value were so considerable that the Industry should be placed in possession of the information contained in it at the earliest possible date; and with the kind consent of Mr. Masterman and the Governor and Directors of the Gas Light and Coke Company, I am pleased to say it was possible to arrange for this. I am sure you will agree with me that this paper is not only of high scientific value, but it is also of very great practical value; and I do hope you will give it the best possible discussion. I should like on your behalf to thank Mr. Masterman and his colleague for the work they have done in preparing this paper for us, and we send our best wishes and thanks also to the Governor and Directors of the Gas Light and Coke Company for placing the facilities at the disposal of the authors for the preparation of the paper and its communication to you.

I should like to welcome on your behalf and mine Sir Leonard Hill, who is attending this meeting to-day, and I will call upon him kindly to open the discussion on this paper.

Sir LEONARD HILL: I am quite unable to criticize Mr. Masterman's valuable paper. I can only see the great practical value it must have to you; but what I have come here to tell you about is what I think is rather a remarkable —if I may say so—discovery I have made with regard to ventilation during the last year. There has always been an unknown source of discomfort which the American authorities have often called the X source of discomfort in shut up rooms, and a great deal has been said about the ionization of air, or the de-ionization of air, as the cause of discomfort, without definite proof having been brought forward. But what I have found out recently is that one great cause of discomfort, and I think a very important cause, is the character of the infra-red radiation. I unfortunately had my septum on the left side of my nose deflected by an old boxing bout, and that side of my nose is very easily shut up, and I have a bit of catarrh on the other side of my nose also. I have found that all people like myself who have catarrhal noses and are liable to obstructed noses behave as I do; but there is another group of people who have open normal noses who are not troubled by the infra-red rays which trouble people like myself. I think all open-air people who have what I might call open-air noses are like myself, while normal people who do not like the open air or who are indifferent to the open air have wide open noses. What I have found out is that there is a group of infra-red rays in the region of 20,000 to 30,000 Angstrom units—in the shorter infra-red region the visible rays end at about 8000 Angstrom units—which, if it is intense enough in the source of heat which we use, keeps the nose wide open. If that group is absent or deficient and the rest of the infra-red rays are in action without that group, then the nose is congested and tends to become shut up. The air way is restricted. The effect is a purely reflex effect from the naked skin; it has nothing to do with any direct effect on the nose, nothing to do with any emanation or anything of that kind. It is purely to do with the infra-red rays acting upon the skin, and, reflexly, through the nerves producing the effect in the nose causing it to become congested, or not congested, narrowing the air way or opening the air way. I found it out myself by having an electric fire in my house. I put up a new house in the country, and in addition to many gas installations I have a small electric fire in my study; and I found that when I sat opposite this electric fire I was uncomfortable. I put the electric fire in front of an open chimney, and I was just as uncomfortable. All the heat or anything else that came off the fire went up the chimney, and therefore it could not be due to anything of that sort, but a screen between the fire and myself immediately took away the discomfort. I found I could go yards away from the fire, but if I faced it I was still uncomfortable. If I turned my back on the fire I was all right.

REASON FOR THE WATER TROUGH BEFORE A FIRE.

I found that cold air playing on my face immediately took away the discomfort. Fanning my face took away the discomfort and wetting my face took away the discomfort. Putting a trough of cold water in front of the fire took away all my discomfort, and I came to the conclusion that I had got at the reason why people put troughs of cold water in front of these dark sources of heat—namely, because certain rays reflexly produced discomfort, and the vapour rising from the trough of cold water in front of the fire acts as a screen and absorbs these rays. I found I could get as far as 47 ft. away from a dull radiant electric fire and still have my nose shut up on the left side, which is the side I have mentioned as being restricted in the ordinary way. At 48 ft., however, my nose was open; at 47 ft. it was shut. Then I investigated other sources of dark heat and found that all kinds of these sources of heat have the same effect. A bright coal fire or a wood fire, however, do not, and a modern gas fire with the best radiants now made does not do it. A brightly burning coke fire does not shut up my nose, but all dull and black sources of heat, steam heaters, hot water radiators, dark heating panels, &c., have this effect—which, however, is counteracted by cold air acting on the skin. Then I found that a bright source antagonizes the dull source. If I had an electric fire shining on my face, the left side of my nose was completely shut up, but if I had an incandescent source shining on my face at the same time, my nose opened. I could make an incandescent source shine on my back or on some other part of my body and it would immediately open my nose.

I began to investigate the sensitivity of the thing, and found that little screens about 1 in. square would produce this reflex effect. If one got near enough to the source and could have 1 sq. in. of skin exposed one got the effect of one's nose being immediately shut up if a dull red source of heat was used. If I then exposed 1 sq. in. of skin to an incandescent source my nose opens. The antagonism between the two was most remarkable, and the sensitivity of the skin to this effect is most remarkable. I have no doubt that most people in this hall are as susceptible as I am. Of all the normal people with wide open noses whom I have yet examined I have not failed in any one case to make them susceptible. I apply a screw nose clip and screw it on the nose until it is obstructed as I am obstructed, and until they can only just live by breathing by one side of the nose. Then I find these people are just as susceptible as I am to this effect, so that it seems to be a general law applying to all of us that we are sensitive to these infra-red rays. It seems to show that there is one group which at once shuts up the nose and congests the nose by a reflex action from the skin, and there is another group which opens the nose.

By investigation with the rock salt spectroscope and the thermopile, and various screens, Mr. H. J. Taylor, my physical colleague, and myself have worked out that the group which opens the nose is this group between 20,000 and 30,000 Angstrom units. Put that group in your sources of heat and you will get all the nose shutting people comfortable. If you do not use that group then you must have plenty of cold air to counteract your dull red source of heat or black source of heat, and you must have plenty of air. I have always insisted that plenty of cool air should go through my rooms. I introduced an instrument known as the katathermometer for measuring the cooling effect of air, and I insisted that there should be standard cooling powers; and I have found out, from the point of view of comfort, that the cooling power of air counteracts these infra-red rays given off from dark sources of heat. We must put enough cool air through our rooms to counteract this effect and produce a comfortable condition. This question of discomfort is an important one because the nose when it is congested produces feelings of headache and discomfort and stuffiness and those conditions which are conducive to catarrhs. All this helps to spread infection, so that getting the right form of heat and the right rays and plenty of cool air, using your flues to the utmost to get cool air through your rooms, are matters of the greatest importance.

ADEQUATE AIR INLETS.

Dr. C. M. WALTER (Birmingham): I should like to congratulate the authors of this paper in that they have given a large amount of information relating to ventilation in connection with gas fires which we have not had available in the past. The paper indicates that an enormous amount of experimental work has been done, and I am sure the information in the paper will be of extreme value, not only to gas undertakings but also to manufacturers of gas apparatus. The authors have mentioned that the restriction acting along the whole path of the air in motion must be taken into account, but it is possible that they have hardly laid sufficient stress on the need for adequate air inlets. With solid fuel firing a great deal more heat passes up the flue than in the case of gas fires, with the result that a greater ventilating force is available and may be sufficient to induce adequate ventilation through cracks and crevices round window frames and doors. That is particularly noticeable if you examine the outside of a window frame of a room in which a coal fire has been burning; you will find an enormous amount of solid matter has deposited there, showing the considerable amount of air taken in through crevices of that nature. With gas fires, where the ventilating force available is lower, it would appear that the inlet openings may need enlarging by the employment of suitable ventilating ducts in different parts of the room, fitted with suitable controls. I should like to ask the

authors whether they have gone fully into this question to ascertain to what extent these auxiliary ventilating ducts might be necessary or advisable. A little difficulty seems to have been experienced in obtaining adequate ventilation with loosely fitted fires, and the requisite flues seem to be smaller than would generally have been anticipated. The flue fitted for solid fuel fire grates presents, under certain conditions, great difficulty compared with the flue constructed for a gas fire, not so much with regard to the actual dimensions of the flue-ways, for these would be much larger than strictly necessary, but in the provision of suitable control. By an arrangement of control of the inlet air with gas fires the inlet air velocity might be considerably reduced and a more even distribution obtained which would result in draughts being reduced to a minimum or entirely eliminated. The difference between the performance of fires sealed and unsealed with respect to the surround is interesting, and it would appear that in the case of the unsealed fire there is no question about getting adequate ventilation under normal conditions.

It is interesting to note the exceptional flatness of some of the curves in figs. 2 and 3. I should like to ask the authors whether after allowing for coefficient of friction and also the square root loss, the flatness of these curves is due particularly to the question of heat loss. It seems extraordinary that the curves are so flat. The important question arising with gas fires as at present designed is whether, without some radical alteration, we can afford to push up the radiant efficiency without seriously affecting the ventilating effect. Assuming that the best adjustment for gas fires is somewhere about 2000 B.Th.U. per radiant per hour —of which at present 1000 B.Th.U. per hour are available for ventilation—it would seem that a ventilation of 100 c.ft. per hour could easily be obtained by 100 B.Th.U., so that there is the prospect that a considerably greater ventilating power can be obtained. This indicates that there is still considerable scope for development in gas fire design even on the present lines without encroaching on the ventilating part of the problem.

Use of Luminous Flame.

The authors refer to the use of a luminous flame in connection with some of the experimental work, and it is stated that the correction for the radiation loss is small. I should like to ask why a bunsen flame was not used in this case, as apparently it is possible at times for the radiation loss from the luminous flame to amount to as much as 20 per cent. Another point which I should like to ask is whether the authors have used in any of their experimental work electrical resistance grids for measuring the air temperature, because in my own experience I have found it extremely difficult to measure accurately the temperature of moving gases in flues with a thermocouple or thermometers owing to the difficulties of thermal gradients. I understand that we can get over the difficulty by arranging resistance grids and checking these temperatures by measuring the difference of electrical resistance. Finally, there is another point and that is that it would seem from the conclusions set out that we might extract from a room—I am speaking from the ventilating point of view—the foul air at a height above breathing level by putting suitable injectors operated from the waste gases of the fire, so that the foul air can be removed at higher levels than at present.

A Spirit of Awakening.

Prof. J. W. Cobb (Leeds University): I should like to say, in opening my remarks, how cordially the University of Leeds and those connected with it welcome this paper from Mr. Masterman, as being indicative of a spirit of awakening in the Gas Industry which promises well for its future—indeed, one might say, as being the only method which will guarantee the future of competitive industry at the present time. The history of the gas fire is exceedingly interesting in the sense that one after the other different points have come forward for emphasis and attention. To begin with, naturally, perhaps, economy in heating alone seems to have been studied, and at that time such standards as we would now apply in matters affecting ventilation were entirely in the background. The Gas Heating Research Committee, which represented the first systematic collaboration between the Gas Industry and the University of Leeds in research, did, I think I may claim, play a part in this splendid pioneer work in making a scientific study of the heat balance existing in the gas fire, at the same time insisting upon the importance which recent work has served to emphasize, of the radiant heat emitted from the fire.

The ventilating effect of the gas fire was even then, by those who were looking at the question closely and scientifically, not by any means unobserved. It was known to be a subject fitting for inquiry, and just before the war two or three years' work had been done by a Committee which at that time was called the Gas Heating and Ventilation Research Committee. That was constituted upon the same lines, and might be regarded as substantially the same Committee, as the one that had done the gas heating research previously. In order to get results which from the outset would have a measure of reliability, there was constructed in the grounds of the University of Leeds a building which eliminated some of the uncertainties which Mr. Masterman has referred to in connection with this type of measurement. The ventilation was effected in what might be described as a room within a room, with a simple flue opening into a restricted space in such a way that, however the winds might be blowing outside, the pressure conditions in the flue, and the flow of air, were maintained with complete steadiness, and allowed proper observations to be taken. In that way a number of figures were obtained which I believe will be of permanent value. But we all realized that that could only be regarded as the first part of the work, if it were to be of maximum utility to the Gas Industry. It was plainly necessary that observations should be extended to conditions much more closely resembling those of practice, and which took into account the vast variety of conditions which practice always entails, extending beyond the observations made under these conditions of simplification which we, quite rightly I think, imposed upon our own experiments. It was only the outbreak of the war, as a matter of fact, which stopped our experiments at the stage I have described. The development which was so desirable is one which has been undertaken, and very capably undertaken, by Mr. Masterman and his colleagues. The result of it we see in the paper which Mr. Masterman has presented, and which contains a most valuable set of results. In connection with ventilation generally, this paper emphasizes very much in its title the fundamental fact which should never be lost sight of by the Gas Industry, and which people outside the Gas Industry ought not to be allowed to lose sight of—namely, that the modern gas fire is not only a source of supply of radiant heat, but that it is also an effective ventilator for all rooms in which it is placed, and that it is the simplest and most effective means of securing such ventilation. That has its importance from the hygienic point of view, as Sir Leonard Hill has already criticized.

A Comparison of Thermal Efficiencies.

I would further like to refer to it in connection with another matter, and that is when comparisons can be made on the thermal efficiency of different types of appliances. When, for example, Sir Dugald Clerk, Prof. Smithells, and myself undertook, soon after the war, a comparison of the thermal efficiencies in connection with gas and electricity, we assumed we could afford to take 100 per cent. efficiency for the electric heater placed in a room, and we assumed an efficiency for the gas fire which counted the heat passing into the chimney as lost; but, as a matter of fact, if the case is looked into a little further, that heat ought not to be taken as lost, because it is the aeromotive force for ventilation purposes, and it is by far the simplest method of applying that force. I believe Mr. Wood is going to speak on some details in connection with this work, and so I will not do that, but I think it would be rather a pity if this kind of paper were used to justify any tendency to cut down to the closest point the capacity of ventilating flues used in connection with gas apparatus—and I am quite certain it is not Mr. Masterman's intention that that should be done. There is, however, a tendency in that direction which has to be guarded against. There is a temptation to press too far the possible advantages to the Gas Industry that may be secured in building construction by the use of small flues of a certain shape. It is also extremely common, and must come within the experience of most of us when a gas fire is introduced for heating in a room in which no proper flue exists, to place a metal flue in the room, with a connection between the fire and the flue, the capacity of which is sufficient to vent the products of combustion, but is only just sufficient for that, and with no ventilation in addition, with consequences to the condition of the air in the room that are very undesirable. That must have come under the notice, I should think, of most of you; it has come under my own notice repeatedly, and it is one of the things which is apt to create a quite unnecessary prejudice against the gas fire. There is the tendency to get the effect to which Sir Leonard Hill has referred without the compensating effect which he has described of a cold air supply, and in such cases the gas fire is not serving the double purpose of a heater and a ventilator. It is simply serving the purpose of heating alone. Physiologically the effect is such as to create a prejudice against the gas fire which is unnecessary; and that is my point, because with a little care in construction and with the use of a flue of reasonable capacity, all the ill effects disappear, and the gas fire comes into its own

and occupies the position that it always ought to occupy as a heating agent.

I might just refer to one point which was raised by Dr. Walter, and that is his question as to whether Mr. Masterman has been able to form an opinion as to whether in practice the inlet friction of the air entering a room becomes a very serious factor, or whether it can be taken that in practice that can always be left to look after itself. It is a very important point. In the ventilation of the building at Leeds University, to which I have referred, the joints were very tight and the air admission was made through a controlled and measurable inlet, and the conditions that could be obtained varied very widely with the area that was allowed, as might naturally be expected. The point I raise is the practical point as to whether, with the actual construction of rooms, that limiting factor does or does not come into play. Another point which was raised by Dr. Walter was the possibility or the usefulness of grid resistance thermometers in such determinations. I might here refer Dr. Walter to the reports of the Ventilation Research Committee, where he will find that such grids were used throughout for measuring both the temperature of the inlet air and the temperature of the gases in the flue. Indeed, the whole arrangement was connected up so that the actual temperatures were not always measured; It was so made that an automatic record throughout was taken, showing the difference existing between the air passing over the grid and entering the room and the hot products of combustion passing up the flue. That was found to be a very satisfactory method, and I can quite understand Dr. Walter feeling some uncertainty regarding the use of thermocouples for that type of measurement. There will be a note on that very subject of the measurement of temperatures by the thermocouples when the temperature of the wall of the flue is different from that of the air passing through it, the corrections that are necessary, and what they amount to in practice, in the next report, which comes before the research meeting in October.

A Note of Warning.

Dr. H. Hartley (Head of Research Department, Radiation Ltd.): It will be realized that with a memorandum of this length, and especially in view of the subject treated, there is much that can be said by way of comment. Both in the Introduction and again in Section 2 there occurs the suggestion that the complete removal of products of combustion of a gas fire from a room is really unnecessary. While this might be true in the case of a fire correctly designed and operating properly, it must not be overlooked that gas fires are often used in a badly adjusted state and with broken radiants. If the view were to gain ground that the advance represented by the "Lancet" test is of little moment, it would be unfortunate. The authors rightly touch upon the importance, in work of this kind, of having "still air" conditions in the vicinity of the experimental chimney. Our experience is that if the chimney passes from one floor of a building to another it is extremely difficult to avoid surge. It is quite out of the question to do such work using a chimney leading directly to the outer air. According to Shaw, a wind moving at about 15 miles an hour across a chimney pot will create an aero-motive force equal to that attained by raising the temperature of the air within a 40 ft. chimney by about 100° Fahr. Bearing such facts in mind, it will be realized that the aero-motive force provided by the fire itself may be appreciably less than that induced by other causes. The authors' tests have, as in the case of our earlier work, been carried out under conditions which avoid any interference due to resistance to the inlet of air to the experimental room. It is possible to calculate reasonably accurately what the effect of such resistance would be.

The resistance of inlet to the room and the resistance of inlet to the chimney are factors which possibly can be controlled, within limits, by a gas company when installing the gas fire. Rarely is it possible to do anything effective to the chimney itself. The effect of variation in the sizes of inlets, both to the chimney and the room, might, I think, with advantage have been treated more fully. The authors mention that the flow of air through the flue nozzle of a 10-radiant fire was only about 1500 c.ft. per hour when the appliance was operating without the aid of any chimney pull. The object of the designer of the gas fire is to make the flue outlet itself as small as possible consistent with the requirements of the "Lancet" test, and to provide additional ventilation by means of a subsidiary opening. The authors do not appear to have endeavoured to differentiate between the amount of air flowing through the flue and the subsidiary openings. One great advantage of the two-flue system is that the subsidiary opening, while leading to an increase in the total amount of ventilation taking place, does in fact cause a decrease in the actual amount of air flowing through the flue of the fire itself, and therefore can be made to minimize the unavoidable increase in total chimney heat which is a concomitant of increased ventilation. With regard to the experimental work itself, so far as I can judge from the photograph of the heat unit, the small burners, owing to their position, must have offered appreciable resistance to the flow of air into the chimney. It would be interesting to know whether the authors checked this point, and, if so, what allowance it was found necessary to make. Also, when using the gas fire, what was the effect of change of direction of the flow of products after leaving the nozzle, and did the disturbance occurring at the foot of the chimney increase the resistance of the latter appreciably?

I should like further information as to the method used for measuring the temperature at the foot of the experimental chimney, and a statement of the degree of accuracy of the results. In what position in the chimney were the temperature determinations made on which the calculation of G_2 and air flow were based? It is a matter of considerable difficulty to assess correctly the amount of heat passing into a chimney from a gas fire. When the system, gas fire and chimney, is examined in detail it will be found to be one of some complexity. How did the authors assess the effective height of their chimney, bearing in mind that the major portion of the energy from the gas fire is introduced via the flue nozzle in a quickly moving stream of gases, while the remainder passes through the back casting at a somewhat lower level? Apart, however, from such factors, which affect the theoretical discussion of the results, it is sometimes difficult when the air flow is small and is measured directly by the aid of a Pitot tube and Chattock gauge, to ensure that repeat results shall agree with one another to within 10 per cent. If the figures given in the last two columns of the tables on pages 38 and 39 of the paper are examined, it will be seen that the variations between the calculated and the measured weights do at times show differences even greater still, both when the total air flow is large and small. Appendix 4 contains some obvious typographical errors, but should not $\frac{MyH}{AU}$ at the top of page 34 read $\frac{MyH}{U}$?

In the concluding sentence on page 33 attention is drawn by the authors to a very useful relationship between the volumes occupied by equal weights of air and their B.Th.U. content. I would suggest they introduce their equation representing this relationship [$W = 0{\cdot}76(AU - \frac{My}{10}$] before the second equation from the bottom of page 34, instead of later, as at present. The sudden appearance of the fifth term is somewhat puzzling on first reading through the publication. The authors have used the value 0·008 for the coefficient of friction in many of their calculations. They say that this coefficient may vary between 0·008 and 0·01. If this latter figure is taken for the calculation worked out on page 44, it will be found that the value calculated for U, instead of being 9·72, becomes somewhat less than 9·0. Again, if the value for the effective heat admitted to the flue were 2 B.Th.U. per second instead of 6, the value for W, on the basis of a friction coefficient of 0·008, would be about 6·6 as against about 6·3 for a coefficient of 0·01. $\frac{S}{A}$ in equation (2) increases with decrease in chimney diameter and $\zeta\frac{S}{A}$ would then become more significant still. Uncertainty as to the value of ζ may thus be a possible cause of variation of about 5 per cent. in the result calculated. Such variation is greater than would be introduced by assuming for the calculations from equation (2) that the total heat entering the chimney was the same as the effective heat. In view of the difficulties of assessing the difference between Mx and My, and the cubic relationship between W and My, little significance attaches to this correction in connection with equation (2)—a fact which the authors mention on page 50. As the flow measurements are based on the determination of a temperature rise, the correction may become significant in the experimental determination of W. By the use of the Pitot tube method of measuring the flow the need for the introduction of My could be avoided. It would, I think, have added to the interest of the paper if some of the results for the 9 in. by 9 in. chimney in Table 1 related more closely to heat inputs corresponding to those attained with gas fires. The smallest gas rate given—namely, 30·5 c.ft. per hour—corresponds roughly to the consumption of the largest gas fire made. In that case the temperature rise was 44° Fahr. I hope they will amend, or add to, this table before the final publication of the paper, and include data relating to smaller consumptions.

The phraseology used by the authors on page 52, "for any normal fire flue increased heat input has appreciable effect on increased induced ventilation," appears to me liable to misinterpretation in view of the fact that a 50

per cent. increase in flue heat would not increase the ventilation by more than 13 per cent. At the end of this section reference is made to the relationship between heat input and ventilation used by Shaw in his well-known publication. When investigating the influence of the various factors affecting ventilation by means of the gas fire, we adopted Shaw's suggestions because of the simplification they effected in the mathematical relationships deduced to connect the aero-motive force, the resistance, and the flow; and I would strongly advise anyone contemplating work in this field with a view to direct application to gas fire installation to study Shaw's deductions. He expressed resistances in terms of areas of holes in thin plates, and this leads to results which can be applied quite simply, without alarming errors. He assumes the aero-motive force in a flue due to heat is a function of $\frac{t}{T}$ instead of $\frac{t}{T+t}$. When it is borne in mind that the areo-motive force set up by the fine is generally less than that resulting from external wind movements, it will, I think, be admitted that Shaw's simplification has considerable justification from the practical point of view.

In conclusion, may I offer the authors my congratulations and thanks? I am glad Mr. Masterman asked me to take part in this discussion, as his request led me to make a careful study of his paper over the week-end, and I ask him to regard my comments as evidence that his results have had careful consideration and his communication has been read with enjoyment.

Mr. A. F. Dufton: I should like to congratulate the authors on their very important contribution to the study of ventilation by means of gas fires. Reference is made in the paper to Sir Napier Shaw's book on "Air Currents and the Laws of Ventilation." The point has been touched upon by Dr. Walter and Dr. Hartley, but perhaps I might amplify it a little. In his book, Sir Napier Shaw finds the equivalent of a chimney of known size in terms of a thin plate orifice. This conception of equivalent area appears to be very useful, and it would be interesting to know whether the authors have found any objection to it. It assumes, of course, that the friction of the kinetic energy and the loss of energy in the eddy due to the turbulent motion of the air passing obstacles of various kinds are large compared with the effect of skin friction. In the experiments of the authors perhaps skin friction was taken as normal, but in Appendix 3 a case is given in which the condensation in a flue is decreased. This has an important bearing upon the deterioration of chimneys. In the case given it is assumed that condensation will occur at temperatures above the dew-point, calculated for pure water; but in practice the condensate is always slightly acid, and my attention has recently been directed to some work by H. J. Johnston, of Illinois University, which shows that a trace of SO_3 in flue gases is sufficient to raise the dew-point very considerably indeed.

The President: I am sorry that again I have to close the discussion, but I trust that those other members who have sent up their names as wishing to speak will accept my apology for not being able to call upon them and that they will send in communications for inclusion in the Proceedings.

Mr. Noble's Reply.

Mr. Noble: Mr. Masterman will deal with the major points, but there were one or two questions asked by Dr. Walter to which I think I can give an answer. With regard to the flatness of the ventilation curves, the fact he notices—viz., that the curve goes up very steeply and then flattens out until it is almost horizontal—is not due to heat loss, at least not as represented on these curves. These curves are plotted for definite heat throughputs through the flue; and if you take into account the heat loss, the curves become even flatter, and they would then even descend somewhat. It is simply due to the natural loss at the openings. What happens is that as the flue gets taller, more air is drawn into the flue and the average temperature is reduced.

With regard to the luminous flame, we are aware, of course, that there may be a considerable amount of heat loss in a luminous flame, by radiation, but it depends on the actual nature and shape of the luminous flame. In our case we did actually measure the heat loss by radiation. As to why we did not use a bunsen flame, the bunsen flame is more complicated to make up, and it must be remembered that we wanted to arrange for a large number of burners. We had in one case 81 burners burning at comparatively small gas rates, and it would have been rather difficult to arrange for bunsen burners. In any case we had to determine what the heat loss by radiation was.

With regard to resistance grids, they have advantages and they also have disadvantages. We used them a good deal for the earliest work on a previous paper, but as in the present case we were aiming definitely at getting a uniform temperature at the base of the flue there seemed to be no need to use the platinum resistance grid or other resistance grid, and we stuck to the thermocouple. We used it because we were particularly interested in the size of the temperature gradients higher up the flue; and for that purpose the thermocouple was essential.

There is one point I might have mentioned about the flatness of the curves mentioned by Dr. Walter. We have actually answered Dr. Walter's point, when we give curves showing the effect of ventilation with and without the allowances for heat loss from the flue. With regard to Dr. Hartley's question, it is true that the smaller the temperature rise in the flue the closer the approximation to the truth becomes the cube expression proposed by Sir Napier Shaw and used by Dr. Hartley and others.

We are definitely advocating the use of smaller flues. We had a 9 by 9 flue which was 30 ft. high, and you do not then get that temperature rise; but we are definitely advocating smaller flues, so that consequently we shall be getting higher flue temperatures and the error will then be greater. There is only one other point, and that is that if the expression is theoretically incorrect it seems to me undesirable to use it. There have been from time to time various expressions which have been alleged to show the relation between heat input and height of ventilation based, perhaps, on inadequate experimental work; and it seems rather a pity to adopt that cube expression when it might lead to considerable errors in the small flues we are advocating.

I was very pleased to see that Mr. Dufton was able to come. He spoke about Sir Napier Shaw's method of dealing with the resistance of thin plate chimneys. We have not used that method, although we are familiar with it. Our own method of expressing the resistance in terms of K—a constant resistance—seems much preferable, largely because of the simple relation which we have derived for the equivalent heating of the flue which is restricted and the flue which is unrestricted. What we want to know is that if we have 10 per cent. of the flue unrestricted and then put a resistance into it, by what amount of heating must we increase to give us the same ventilation as before; and the very simple relation is shown, both theoretically and experimentally, that the height of the one is to the height of the other as $1 : 1/K$, where K is the constant resistance, the value of which we give.

The point about the effect of acid gases—SO_2 and SO_3—on the dew-point of the flue gases is quite interesting. I have been in touch with Mr. Johnston in America, and it is true that his results show that the dew-point is raised considerably by quite small amounts of SO_2. However, our own calculations seem to show that the amount of sulphur in our flue gases is well below the amount which might appreciably be affected at such dilutions as we are concerned with, and further, in general, we get quite a reasonable agreement between the calculated and the measured condensation temperature.

Mr. Masterman's Reply.

Mr. Masterman: The point Prof. Cobb mentioned with regard to air entry to the room is affected by the character of the tests we have been attempting. We set out to try to discover the size of flue which should under practical conditions be used to obtain correct ventilation of the room. There is a good deal of evidence that the correct ventilation of a room lies between two and four air changes per hour. The builder is then given some guidance, we hope, as to the size of the flue he should use to produce a normal ventilation. There will be adequate inlet and exit, but if the people using the house subsequently put rubber against every crack, and paper against every hole, naturally these are circumstances which the builder cannot avoid. This is a point we have not gone into or discussed to any large extent—namely, the air entry into the room—bearing in mind the fact that a number of tests some years ago at Leeds University dealt with that very subject. Prof. Cobb suggested that we were aiming, and possibly wrongfully aiming, at cutting down the size of the flue. We are indeed aiming at that. We are aiming at giving data which will be a definite guide so that people will know what size of flue can be used to obtain the ventilation required, and the various things which may militate against that flue giving its correct performance; and in the end one does discover—and I think we all know—that one can effect very considerable building economies indeed by using surprisingly small flues. It is no use building large flues and then blocking them up and so reducing the ventilation going through because there is an excessive up-draught or down-draught. We may as well effect the economies in the actual construction. I can only add how we appreciate the comments made about the paper, and I certainly shall look forward to reading the written comments, which I hope will be arriving very soon.

A Method of Analysing Gas Output Curves

By Dr. J. S. G. THOMAS,

Senior Physicist, The South Metropolitan Gas Company

INTRODUCTION.

Within recent years attention has been drawn in the Technical Press to the need for more statistical information relating to the supply and use of Town's gas. To quote from a recent article[1]: " It has to be admitted that we have not sufficient data to permit of any real planning,

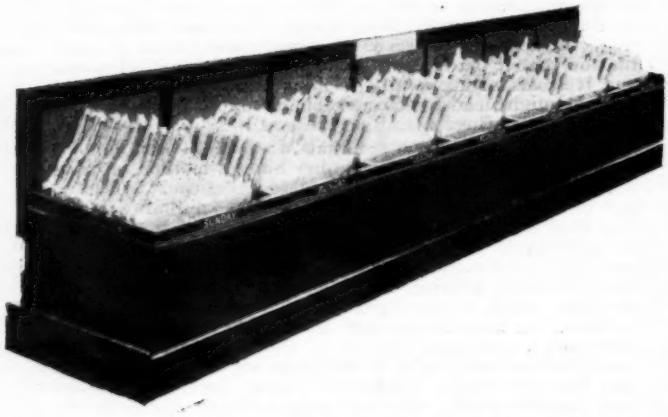


FIGURE 1.—*Device for showing at a glance the Hourly Output for each Day over a Period of Years.*

and without planning, progress must be haphazard. First one undertaking and then another suddenly wakes up to the fact that it is losing load at an alarming pace to the other fellow. Then, but not until then, there is some attempt to stop the leak. But then there arises the difficulty that there is not a scrap of reliable information on which to base the defensive measures."

I am quite unable to express an opinion as to how far this charge may or may not be justifiable with regard to the Gas Industry of this country generally; it certainly is a charge to which the South Metropolitan Gas Company can plead Not Guilty. Its detailed records of the supply and installation of gas-consuming appliances go back to 1892; since 1902, records have been kept of the hourly output of gas from all stations of the Company, together with a brief statement of the corresponding atmospheric and climatic conditions. For purposes of easy and convenient reference, and in order to enable one to obtain at a glance a " bird's eye view " of the supply over a period of a year or so, permanent records of the hourly output for each day are cut in cardboard and assembled in a series of trays, one of which is shown in Figure 1.

Much is to be learnt from these records and the principal purpose of this Paper is to show how they may be employed to afford information relating to the proportions of the Company's lighting and other loads.

I wish to express my sincerest thanks to Dr. Charles Carpenter, President of the South Metropolitan Gas Company, at whose suggestion this analysis was undertaken, and who has been throughout, its inspiration; whatever merit it may possess is attributable to his suggestions and criticisms. Mr. E. V. Evans and Mr. A. Stokes, Joint Managers, have provided all the data on which the analysis is based and have discussed the results with me.

[1] Gas World, 1932, April 30, 1932, Vol. 96, p. 429.

I. DERIVATION OF TOTAL LIGHTING LOAD.

In Figure 2 is reproduced a graph, the greater part of which relates to Wednesday, 8th January, 1930. It is a graph typical of a normal winter day's gas output. Abscissæ represents the hours, commencing with 6 a.m.; ordinates represent hourly rates of gas output expressed in therms. The graph is characterized by three well-marked peaks occurring respectively at about 9 a.m., 1 p.m., and about 6 p.m. Thereafter the gas output falls off steadily until about 2 a.m. on Thursday morning, and then increases, at first slowly and afterwards more rapidly to the first peak of the Thursday graph. The significance of the peaks is clear; they correspond, in sequence, to the incidence of a cooking load at breakfast time, a mid-day cooking load, and a cooking and lighting load subsequent to sunset. The letters inserted in the areas into which the diagram is divided by the ordinates AB and CD refer to the loads, viz., heating (H), lighting (L), cooking (C), and industrial (I), which are associated with the respective areas.

The amount of the public lighting load is, of course, known from the Company's lamp records. It has been indicated on the Figure 2 by the letters P.L.

A notion of the total lighting load is readily obtained from a comparison of the output records for typical summer and winter days, the same day of the week being selected in each case, and abnormal days such as Bank Holidays, foggy days, &c., avoided.

The record for such a summer day, Wednesday, 19th June, 1929, is set out in Figure 3, together with the record for Wednesday, 8th January, 1930, already given in Figure 2. The respective times of sunset on the days in question were 9.20 p.m. and 4.10 p.m. The summer day record is represented by the broken graph, and the much later incidence of the evening lighting load compared with that for a winter's day is represented by the ascending part C'K.

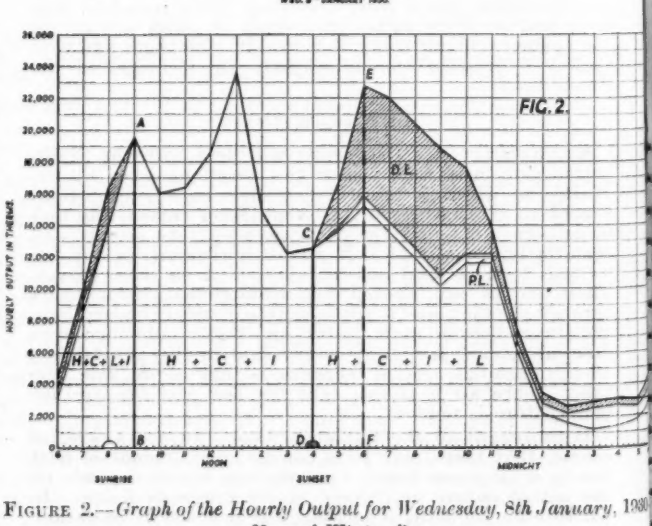


FIGURE 2.—*Graph of the Hourly Output for Wednesday, 8th January, 1930, a Normal Winter Day.*

Clearly we may say that, very approximately, the difference of ordinates of the respective curves included between CD and C'D' is attributable to the lighting load on the winter day in question and to additional heating and cooking on this latter day owing to its seasonal difference from the summer day. An approximation to this winter

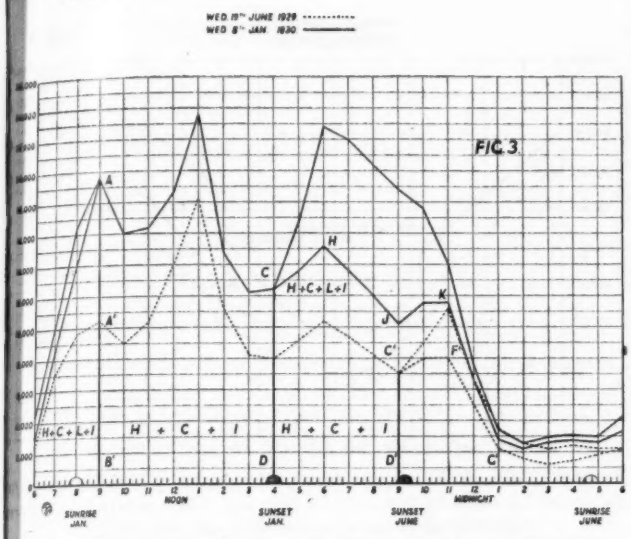


FIGURE 3.—*Comparative Graph of the Hourly Output for Wednesday, 19th June, 1929, and Wednesday, 8th January, 1930—Normal Summer and Winter Days.*

day's additional heating and cooking load is given by the average difference of ordinates of the two graphs between the ordinates AB' and CD where, in both cases, there is no lighting present. If then the ordinates of the summer curve between CD and C'D' be increased by the average percentage difference of the ordinates of the two graphs included between AB and CD and a new graph be drawn through the points so obtained, the area included between the new graph and the winter day's graph will represent the total lighting load between 4 p.m. (CD) and 9 p.m. (C'D') on the winter day in question. This procedure has been followed and the portion of the new graph represented by CHJ has thus been derived. The same procedure cannot be followed for the hours subsequent to 9 p.m., as the form of the graph past 9 p.m. on the summer day is already determined in part by a lighting load.

Before the procedure already detailed can be followed on the part of the summer day's graph subsequent to 9 p.m. this summer day's lighting load must be deducted from the ordinates concerned. It is not unreasonable to assume that this lighting load subsequent to 9 p.m. on the summer's day is the same percentage of the total load after 9 p.m. as that characterizing the load between 4 p.m. and 9 p.m. on the winter day's curve. The graph C'F'G' derived in this manner may be taken to represent approximately the graph of the summer day's load after

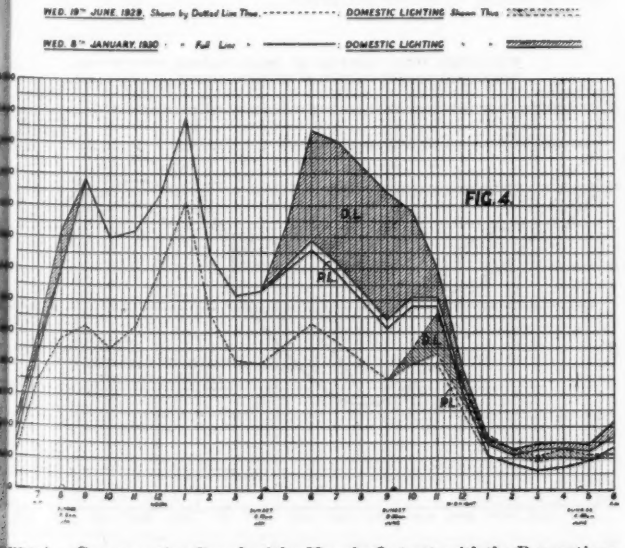

WED. 19TH JUNE 1929. Shown by Dotted Line Thus. ---------- DOMESTIC LIGHTING Shown Thus
WED. 8TH JANUARY 1930 : " Full Line " ———— : DOMESTIC LIGHTING " "
FIG. 4.
DL
PL
PL
NOON
MIDNIGHT

FIGURE 4.—*Comparative Graph of the Hourly Output, with the Proportions due to Public and Domestic Lighting, for Wednesday, 19th June, 1929, and Wednesday, 8th January, 1930—Normal Summer and Winter Days.*

9 p.m. exclusive of the lighting load. The ordinates of C'F'G' can now be proportionately increased as already detailed and the graph JK derived to represent the winter day's load for the hours after 9 p.m. exclusive of the total lighting after that time. A similar procedure is followed in deriving a notion of the lighting load over the early parts of the graph up to A.

Figure 4 represents the nett result of the lengthy but not difficult calculation involved in what I have attempted to describe. The domestic lighting load (DL) is represented by the shaded area of the figure.

It may be advanced that the analysis whereby we derive our notion of the lighting load does not take into account the seasonal difference in the social characteristics—*e.g.*, the greater home-keeping habits of the people in winter. So far as results obtained hitherto are concerned such criticism of the analysis is probably to some extent justifiable. In order to determine how far our deductions were influenced by such seasonal social characteristics it was considered desirable to obtain an estimate of the lighting load from graphs relating to days not so widely separated in time as a summer and a winter day.

Graphs relating to 26th January, 1931, and 16th March, 1931, on each of which days the atmospheric temperature was 42° Fahr. and the weather conditions fair, are given in Figure 5. It is interesting to note that these

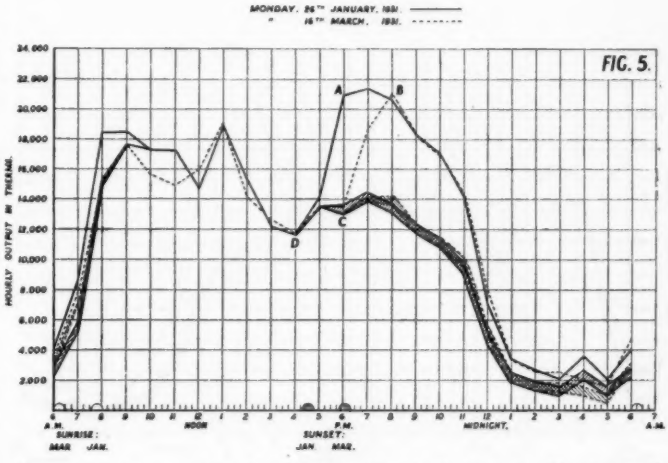


FIGURE 5.—*Comparative Graph of the Hourly Outputs for Monday, 26th January, 1931, and Monday, 16th March, 1931.*

two graphs are not markedly different before 4.30 p.m. (the time of sunset on 26th January) and after 8 p.m. Moreover, the commencement of the sharp rise to the respective maximum loads corresponding to A and B correspond, as in all cases, with the hour of sunset. It is clear that on these two days the heating load was the same. In such a case as this the lighting load is very easily determined from a consideration of ordinates of the area ABCD.

In examining the Company's records we have not been able to find many cases of graphs, having practically coincident portions over parts of their range such as this, to which the analysis is more easily applied, as no allowance for heating has to be made. More customarily we have had to consider graphs such as those shown in Figure 6 corresponding respectively to a day in March with a temperature of 46° Fahr. and a day in April with a temperature of 61° Fahr. In the analysis applied to graphs of this kind, allowance must be made for the different heating load on the two occasions.

It is interesting to note that whether our notion of the amount of the lighting load on any day be derived from the comparison of the load of a summer day and that of a winter day or from the respective loads on days less widely separated in time, consistent results are obtained, the calculated results differing amongst themselves by not more than 3 per cent.

In Table I. are set out numerical particulars derived from Figure 4 and relating to a typical winter and summer day respectively.

TABLE I.—*Comparative Figures Showing the Distribution of the Total Load amongst Various Uses of Gas on typical Winter and Summer Days.*

—	Winter Day. 8th Jan., 1930.	Summer Day. 19th June, 1929.
Total gas output during 24 hours	319,200 therms	190,500 therms
Gas output during lighting hours	205,200 ,,	36,300 ,,
Total gas lighting load	55,700 ,,	10,100 ,,
Domestic lighting load	47,000 ,,	6,500 ,,
Public lighting load	8,700 ,,	3,600 ,,
Total lighting load expressed as a percentage of the total daily output	17·4 per cent.	5·3 per cent.
Public lighting load expressed as a percentage of the total daily output	2·7 ,, ,,	1·9 ,, ,,
Domestic lighting load expressed as a percentage of the total daily output	14·7 ,, ,,	3·4 ,, ,,
Domestic lighting load expressed as a percentage of the output during the lighting period	22·9 ,, ,,	17·9 ,, ,,
Total lighting expressed as a percentage of the output during the lighting period	27·1 ,, ,,	27·8 ,, ,,

These results refer of course only to the days specified. Long arithmetical calculations are necessary if the daily variation of the lighting load over the period of a year is to be ascertained. The time at the Author's disposal

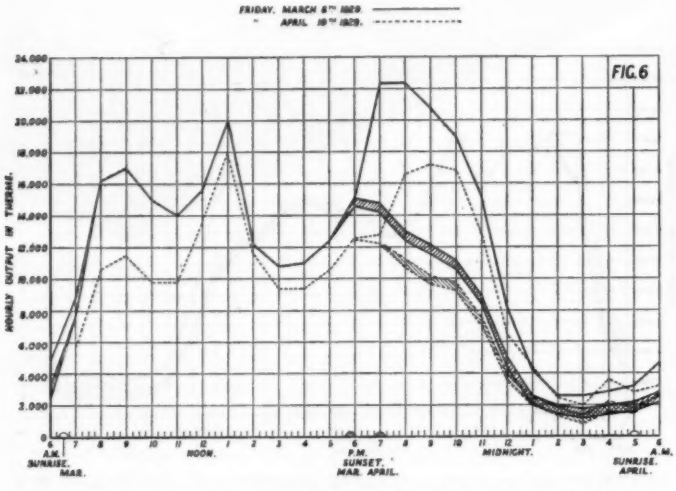


FIGURE 6.—*Comparative Graph of the Hourly Output for Friday, 8th March,* 1929 *(temperature* 46° *Fahr.), and Friday,* 19*th April,* 1929 *(Temperature* 61° *Fahr.).*

was insufficient to make possible this detailed examination of the available material in time for the publication of this Paper. Instead, graphs relating to 74 days uniformly distributed throughout the year 1931 were analysed in the manner described above and the result of this analysis for 1931 and January, 1932, is summarized in the graphs given in Figures 7 and 8, the former giving the actual lighting outputs (domestic and total) for the different months, and the latter these outputs expressed as a percentage of the total daily output. The respective periods of darkness up to midnight are also inserted as a graph. The calculated output figures all lie very close to the graphs drawn, the maximum deviation from the curve in each case being less than 1 per cent.

The incidence of " summer time " in April (A) and the reversion to ordinary time in October (B) is seen to decrease the lighting load by about 2½ per cent. in the first case (*i.e.*, in April) and to cause an increase of about 1½ per cent. in the second case (*i.e.*, in October). That the percentage decrease in April is greater than the percentage increase in October is clearly attributable to the fact that one hour is a greater proportion of the lighting period in April than in October, as the sun sets later in April than in October.

It is not without interest to note the flattening of the graphs in the region CB corresponding to the months of August and September. The diminished consumption

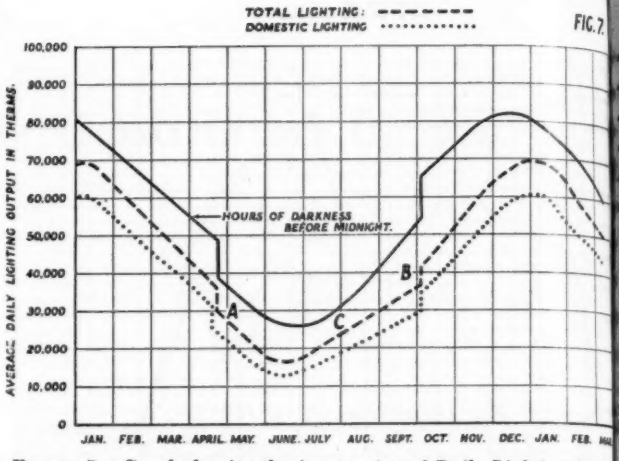


FIGURE 7.—*Graph showing the Average Actual Daily Lighting Output for the period* 1*st January,* 1931, *to* 31*st January,* 1932, *together with a Curve showing the Hours of Darkness before Midnight.*

indicated by the flattening is clearly attributable to these months being the customary holiday months. And here it may be remarked that very clear evidence of the decreased " home-staying " characteristics of the people in recent years associated with the growth of attractions such as outdoor sports, super-cinemas, dog-racing, &c., is derivable from the consideration of the slight changes which have occurred and are occurring in the output graphs during this period. It is not however our purpose to deal with this matter here.

We would however like to draw attention to the effect of a maximum exodus of the people from their homes upon the output load. This is very clearly seen from Figure 9, in which the graphs represent the outputs for 3rd August and 17th August, 1931, the former date being Bank Holiday. It will be noticed that while each graph is characterized by a well-marked evening lighting load, the peak loads associated with times of cooking have practically disappeared from the Bank Holiday graph. The exodus of the people from their homes is most marked by a decrease of the cooking load. The significance of the graphs crossing at A is evident—it is attributable to the late return of some of the revellers to their homes after the holiday festivities.

II. LONG PERIOD VARIATION OF THE OUTPUT AND LIGHTING LOAD.

It is now proposed to discuss very briefly the variation of the form of the output graph and of the lighting load over a period of about 30 years.

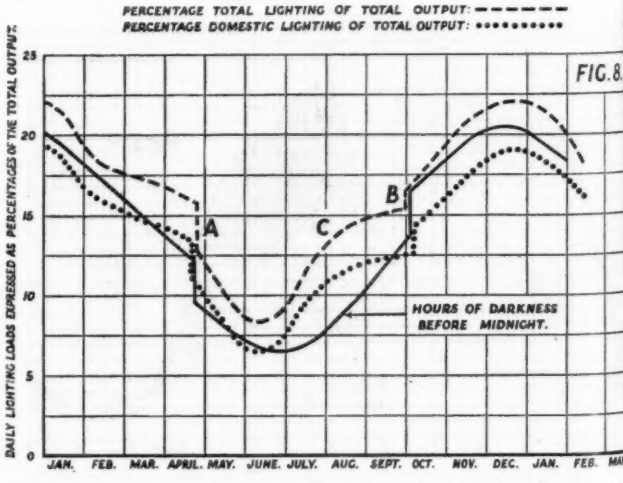

PERCENTAGE TOTAL LIGHTING OF TOTAL OUTPUT:
PERCENTAGE DOMESTIC LIGHTING OF TOTAL OUTPUT:
FIG.8.
DAILY LIGHTING LOADS EXPRESSED AS PERCENTAGES OF THE TOTAL OUTPUT.
A
B
C
HOURS OF DARKNESS BEFORE MIDNIGHT.
JAN. FEB. MAR. APRIL MAY. JUNE. JULY. AUG. SEPT. OCT. NOV. DEC. JAN. FEB.

FIGURE 8.—*Graph showing the Daily Lighting Output as a percentage of Total Output for the Period* 1*st January,* 1931, *to* 31*st January,* 19[illegible] *together with a Curve showing the Hours of Darkness before Midnight.*

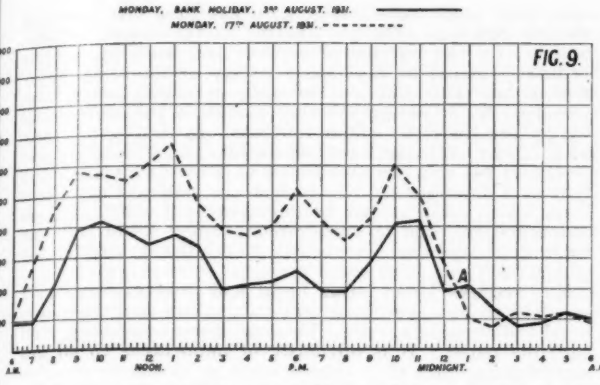


FIGURE 9.—*Comparative Graphs of the Hourly Output for Monday, 3rd August, 1931—Bank Holiday—and Monday, 17th August, 1931.*

A graph for a typical winter day—Tuesday, 15th December, 1903, is given in Figure 10. It is characterized by a very pronounced evening lighting load. The form of the graphs should be compared with those in Figure 4, for these latter graphs show a levelling out of the load in recent years, attributable in part to an increase of the heating and cooking loads, in part to a decrease of the total lighting load.

The respective lighting loads for a winter and summer day, at intervals over the last 29 years, determined from a series of output graphs is given in Table II. below.

TABLE II.—*Showing the Total Lighting Load as a Percentage of Total Output, for a Winter and a Summer Day of the Years 1903, 1913, 1921, and 1931.*

Year.	Total Gas Used for Lighting. (Therms).	Output of Gas for 24 Hours. (Therms).	Percentage of Total Output Used in Lighting.
WINTER DAY (December).			
1903	132,000	290,400	45
1913	108,500	295,100	37
1921	76,600	298,000	26
1931	71,100	316,000	23
SUMMER DAY (June).			
1903	38,100	152,100	25
1913	29,700	166,700	18
1921	13,300	179,900	7·4
1931	16,600	206,800	8

The comparatively and absolutely large outputs for lighting purposes in the early years is associated with the use of relatively inefficient light sources in those years. A marked initial decrease of the lighting load is to be anticipated from the elimination of the inefficient flat flame burner and the introduction of the very much more efficient incandescence burner. It is interesting to note that since 1921 there has been a decrease of only about 2 per cent. in the Company's output of gas used for lighting purposes.

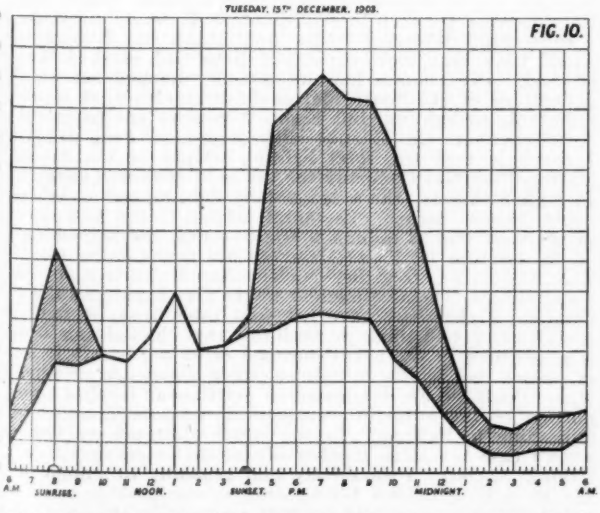


FIGURE 10.—*Graph showing the Hourly Output and the Lighting Load for Tuesday, 15th December, 1903—a Normal Winter Day.*

III. ESTIMATION OF HEATING AND DOMESTIC LOADS.

It remains to say a little as to how an estimate of the heating and domestic loads (including cooking and domestic water-heating) is to be derived from the graphs. It is clear that of the three loads—lighting, heating, and cooking (including water heating)—the former two are seasonal and variable, attaining a maximum in the winter, while the cooking load is of a more constant character, varying mainly only from day to day of the week. A maximum cooking load on Sunday is succeeded by a minimum cooking load on Monday. For the rest of the week the cooking load is fairly constant. The marked feature of this load is its comparative constancy throughout the year apart from exceptional occasions. It follows that if from any of the output curves we deduct appropriately the lighting and heating loads the resulting graphs should be practically superposable. How far this is the case is clearly brought out in Figure 11 where output graphs for Tuesday, 17th March, 1931, and for Tuesday, 26th August, 1930, are drawn, the axis of abscissæ of the latter being moved upwards through a range of about 4000 therms per hour.

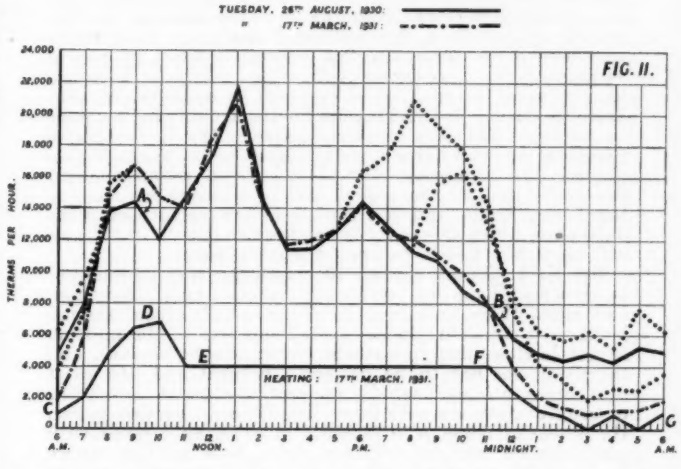


FIGURE 11.—*Comparative Graph of the Hourly Output for Tuesday, 26th August, 1930, and Tuesday, 17th March, 1931.*

Atmospheric temperature on the latter date was 78° Fahr., and it may be assumed justifiably that domestic heating on that day was extremely small and negligible. It is seen that the graphs, after elimination of the lighting and heating loads are practically coincident between the hours 11 a.m. and 11 p.m. The graphs differ slightly before and after these respective hours (see regions A and B). The heating load is now readily determined for 17th March. EF represents the practically constant day heating-load. The parts CDE and FG have ordinates respectively equal to the difference of ordinates of the March and August graphs from which the lighting loads have been deducted.

It is now possible to draw up a fairly complete schedule of the distribution of the total load amongst the various uses of gas on the two days in question. The public lighting and industrial loads are known from the Com-

pany's statistics. The result is shown in Table III., below.

TABLE III.—*Showing the Distribution of the Total Load amongst the Various Uses of Gas, on 17th March, 1931, and 26th August, 1930.*

	Tuesday, 17th March, 1931. Temperature, 42° Fahr.		Tuesday, 26th August, 1930. Temperature, 75° Fahr.	
	Load. (Therms).	Per Cent. of Total Load.	Load. (Therms).	Per Cent. of Total Load.
Domestic lighting	47,800	16·4	26,200	13·9
Public lighting	6,600	2·3	5,400	2·9
Industrial uses	20,400	7·0	15,800	8·4
Domestic heating	74,900	25·8	..	..
Cooking (including water heating)	140,900	48·5	140,900	74·8
Total	290,600	100·0	188,300	100·0

DISCUSSION.

The PRESIDENT: I am sure you will agree with me that Dr. Thomas in this paper has described a method of analyzing gas outputs which is easily applicable, as he has told us, in the case not only of large undertakings but also in the case of even the smallest undertakings, and one cannot over-estimate the value of the information that is to be derived from this method of analysis. I will not in any way delay the discussion because I want to give it as much time as possible; but before doing so, I should like on your behalf and on my own to express our very grateful thanks to Dr. Thomas for the trouble he has gone to in preparing this excellent paper. We have also to thank Dr. Charles Carpenter (President of the South Metropolitan Gas Company) for having given permission for the publication of the paper, and in addition we have to thank Mr. Evans and Mr. Stokes who have furnished the data upon which the analysis has been founded. I will now call upon Mr. Evans to open the discussion.

Mr. E. V. EVANS (South Metropolitan Gas Company): I am afraid I am not very good at opening a discussion, and when there has been no notice at all given, though I am very delighted to do so, it lands one in the position of not having time to consider what should be said, and therefore one has to be perfectly natural and say what first comes into one's mind. In the first place, I should like to congratulate my colleague, Dr. Thomas, on this paper. He is one of those who delights in enjoying himself with mathematics, and, in addition, he is in a position where he has time to think, which to gas engineers is a very difficult matter in these days. With regard to his paper, it seems to me that it hinges very largely round the maintenance of the lighting load. There is, or perhaps I should say there was, a school that was becoming very much discouraged by the alleged preference for electricity for lighting purposes. It has, of course, its advantages, but in a district like South London, where there are so many people who have to exist on a limited wage, lighting by gas is not only exceedingly popular but it is something that will go on for very many years. Therefore, it becomes necessary to give the most careful attention to the service that we are rendering to our gas lighting consumers. I hope it will not be a perennial of mine when I say that the standard of adjusted and fixed air and gas supply, in my opinion, helps very largely to maintain this and other loads. It makes the problem of gas manufacture at the works somewhat difficult, for not only has the calorific value to be maintained constant—and that we do to-day—but very careful attention has to be given to the specific gravity. That sometimes means that there must be a limit on the variations in the quantity of carburetted water gas, or water gas used as a diluent, and the question is, If we do not make water gas, what shall we do with the coke that remains for disposal? The answer to that is that you will get just as busy in the sale of your coke as you have been in the sale of your gas. There is indeed a wonderfully wide field for the use of a high-quality coke, and I am sure that none of us have yet tapped that market. Perhaps I might incidentally suggest that the time has come when we should very seriously question the wisdom of using imported oil for carburetting purposes, particularly with the country in its present difficulties. We on the technical side have still an immense amount to do in improving lighting. Those of you who have electricity in your homes would perhaps be well advised to do a good evening's work with your table lighted with electricity, on the one hand, and then, the next evening, replace it by a well-designed gas burner. I am absolutely certain that you will find there is much greater ease and much greater comfort, and that you will do work without getting tired much more easily with gas than you will with electric lighting. The gas lighting of the future, I think, will be, for the purpose of reading and working, not the ordinary mantle as it is made to-day or the ordinary reflector, but there will be a carefully arranged spectral distribution by adjusting the rare earths of the mantle and by getting the right colour reflector. In that way a most wonderfully soft light can be produced. Physicists and technical gas men are at work on that at the moment, and that is a development to which I am looking for a great deal. As I said at the commencement I was called on spontaneously, and in these circumstances I can only say what first comes into my mind, but I thank you for the opportunity you have given me.

Mr. STEPHEN LACEY (Gas Light and Coke Company): I am glad to have an opportunity of making a contribution to the discussion on Dr. Thomas' very interesting and valuable paper. It is obviously of importance to all gas undertakings that they should know as closely as possible what proportion of their total gas output is attributable to gas lighting. If you ask a gas engineer what proportion of his load is attributable to lighting, you may get any sort of answer. He may say 20, 30, or 50 per cent., but whatever answer he gives it is unlikely that he will have any real evidence to base it on. Dr. Thomas has shown us a way of getting very accurately at the proportion of the total output that is attributable to lighting. I am particularly interested in his methods, because for many years I have had daily output curves of my Company, and the analysis of them has been a hobby of mine. It may be remembered that in 1920 I read a paper to the London and Southern District Junior Gas Association in which I drew attention to the great value of graphical representation of gas output, and I published daily output charts from 1889 onwards for the Gas Light and Coke Company. I was concerned then primarily with distribution costs, and I applied to the Gas Industry the criterion of load factor with which we are so familiar in connection with the electrical industry. I have used these charts in very much the same way as Dr. Thomas has. Dr. Thomas has explained that the chief difficulty in assessing the lighting load by the comparison of daily output curves for the different seasons of the year lies in making the necessary corrections for temperature with regard to the various parts of the load. At the end of the paper Dr. Thomas makes an estimate for the heating load, and he comes to the conclusion, by comparison of a number of winter and summer charts, that the heating load is uniform throughout the day, and he also assumes that the cooking and water heating load are practically unaffected by temperature. I am not quite sure whether that is really the case. I think it is obvious anyhow so far as the water heating is concerned that it must be to some extent affected by temperature, because you start in the winter with water at a very much lower temperature than in the summer. Nevertheless, I think Dr. Thomas' conclusion is probably about right. When he is considering the derivation of the total lighting load in dealing with the summer chart interlined with his winter chart, however, he makes rather a different assumption. If we are to accept the conclusion in the last part of the paper that only the heating load is affected by temperature, he should have added to the ordinates of his summer chart between the hours of 4 p.m. —*i.e.*, the hour of sunset in the winter—and 9 p.m.—the hour of sunset in the summer—not the average percentage increase in the ordinates during the daylight hours, but the difference between these ordinates. It would not make a substantial difference to the final chart, but I think it would have been more consistent if he had adopted that method. Dr. Thomas has not actually worked out what percentage of the South Metropolitan total output is attributable to lighting, but Figure 7 enables one to get at it. From that (Dr. Thomas will correct me if I am wrong) I conclude that the total lighting output of the South Metropolitan Gas Company for the year 1931 was roughly 15 million therms; the average daily lighting output being about 40,000 therms. The total output of the Company in the year was 93 million therms, so that the percentage of the lighting load was about 16 per cent. of the total. That I must say is rather smaller than I anticipated. If we apply Dr. Thomas' method to the Gas Light and Coke Company's charts—I have not had time to do it really completely yet—I think we shall find that the lighting load is somewhere in the neighbourhood of 10 per cent. It is, of course, important to express these figures in another way. What we are interested in gettting at is what proportion of the automatic consumers' consumption is attributable to lighting. In the South Metropolitan Company's case the total number of automatic consumers is, I think, 323,000. I should say that probably 10 million of the 15 million therms for lighting is attributable to the automatic consumer, and on that assumption the lighting consumption per automatic consumer is of the order of 30 therms. I think the total consumption per automatic

consumer in the South Metropolitan Company's area is extraordinarily high. It is about 143 therms, and the lighting consumption is, therefore, between 20 and 25 per cent. of the total. I think that is the right way to express these figures, because clearly when you are lighting, as we all are, for our lighting load we want some criterion of the amount of money that we are prepared to spend in holding it, and I think the actual cost of maintaining your lighting should be expressed in terms of pence per therm of lighting consumption.

One other point I should like to make before sitting down is this. We are talking here of gas lighting as if it were a load quite distinguished from gas heating. Of course, the remarkable thing about gas lighting surely is that it is also heating. In fact, my own view is that it is in circumstances where you can put a money value on the heat associated with light that we are in our strongest position. Many poor people who have adopted electric lighting in place of gas have found to their cost that they have not only to pay more for their lighting, but they have also to spend additional money in producing the heat which they have lost. I think that is a point which we should always keep in mind in fighting for the retention of gas lighting, because I am sure it is of fundamental importance. Of course, the same is true of gas lighting in other circumstances. Take, for instance, church lighting. I am sure nearly all of you can recall a case where gas lighting has been displaced by electricity in churches, with the result that the church which used to be comfortably warm became impossibly cold, and very likely involved spending more money in gas radiators than was spent previously for gas lighting. The same is true, of course, in factories.

I do not think that I have anything more to add, but I congratulate Dr. Thomas very heartily on a most interesting paper, and I would like to say again how much I think the Gas Industry is indebted to the South Metropolitan Gas Company for publishing these figures. As Dr. Thomas has said, any child can do it, and I hope the results of the publication of this paper will be that all gas undertakings will set about using these output curves for making as close an estimate as possible of their lighting load.

Mr. W. J. A. Butterfield: I did not expect to be asked to speak on this paper, and I am afraid I am not competent to say anything of value. I should like, however, to express my great appreciation of the facility with which Dr. Thomas handles figures and data, and to say that I think it is of great value to the industry to be shown how to deal with the data once they are collected and to draw inferences such as he has been able to draw from them. With regard to the lighting load, I think there is no doubt that any undertaking which loses the lighting load loses a great deal more. Perhaps I may refer to one instance which came to my knowledge some years ago. I had occasion to visit a town which had two railway stations —one at each end, about a mile apart—and they were lighted by gas. I walked from one station to the other in the dusk, and in the whole of that walk through the town I saw only one other case of gas lighting visible from the street. The management of the gas undertaking of that town were, they said, out to catch a larger load than lighting, and did not care about lighting at all. To my mind, however, in losing the lighting load they lost in a number of premises the other load for heating and cooking, and the loss of the lighting load in these premises, to my mind, more than counterbalances the bigger load which that administration was out to catch. I think subsequent events have shown that their policy has not been of any real advantage. Personally I am quite convinced that once the lighting load in the smaller houses goes, the heating and cooking load is going also. The installation charges on one source of energy for lighting and another source of energy for cooking and heating are too great for the total rental. The rental will only pay the installation charges of one service and give a proper return, and on that account I think gas undertakings should make every possible effort to retain the lighting load. Further, I think we should not merely emphasize that gas lighting is economical, but we should also stress the point that it is a most comfortable means of lighting in regard to the work to be done. I have the opportunity of observing a number of rooms used as offices, where both gas lighting and electric lighting are available and are maintained in reasonably good condition. Whenever there is continuous work to be done, those using the offices almost invariably use gas lighting, and do not mince matters at all. They say that they find it much more comfortable to the sight, and you hear fewer complaints of having to consult the oculist and to change spectacles, &c., if you stick to gas lighting for strenuous, continuous work. There is just one other point, if I may suggest it—namely, that a large proportion of the research in the industry should, I think, be directed to improving the switch. That is the one thing needed to enable gas to retain the lighting load. The present switches, which you know better than I do, are satisfactory up to a point; but if it were possible to find a self-lighting system which did not need a by-pass gas lighting would advance with very great strides. I think some of the money devoted to research in the interests of the industry would be well spent if directed towards the improvement of switches for lighting purposes.

Mr. Robert Watson (Doncaster): Although the President has expressed our thanks to Dr. Thomas for his very able paper, it is very difficult for a speaker to get up to discuss the paper without also expressing his thanks for the contribution. However thorough may be our card index records of gas appliances used in the houses or on the premises of our consumers, it is difficult to do more than make an intelligent guess as to the quantity of gas used for any particular purpose, whether it be lighting, heating, cooking, or any other use. As a consequence, methods such as Dr. Thomas has indicated this morning, which are such that all of us can use, give us a very valuable indication as to the load which we obtain from each class of appliance, and, therefore, the direction in which we can apply our energies to fill up the low portions of the curves on our various graphs. My remarks will be more of a general character, inasmuch as some of the points I might have referred to have been so well and adequately dealt with by previous speakers. I am indeed glad to know, and I am sure you will all be pleased to know, that the gentlemen who have spoken—namely, Dr. Thomas, Mr. Butterfield, and Mr. Lacey—are all serving on the Joint Lighting Committee which has been established by this Institution, and you can easily understand that the efforts of these gentlemen, supplemented as they are by the resources of their companies—which those of us who are in charge of small undertakings unfortunately have not available—are a very valuable help to that particular Committee. It is difficult to say how much that Committee can achieve. There are obviously many points to consider, many improvements which we should like to effect, which may require time to consider, but it is encouraging to have such a paper as Dr. Thomas', which indicates to us a method of analysis from graphs which are prepared from data in our undertakings. The paper is used principally to examine the gas lighting load, and when companies like the South Metropolitan Gas Company and the Gas Light and Coke Company are able to retain, as they have done, the lighting load to such an extraordinary extent as 16 per cent. and 10 per cent. respectively, and when we realize also, from Dr. Thomas' figures, that they have only sustained a drop in their percentage of lighting load of 2 per cent. during the last ten years, it does afford very great encouragement to those of us who are trying to retain the lighting load to think that it is possible, by effort and by attention, as these two companies are doing, apparently, by making improvements in lighting appliances, to retain what is a very valuable load. I do not altogether rely on percentages. Mr. Lacey spoke of 10 per cent., but it is more a question of quantity—the relative percentage, of course, becomes lower as one obtains an increase in output due to other uses, such as cooking, &c. Dr. Thomas' figures show that when he says he gets 22 per cent. lighting load in the winter and 8 per cent. in the summer, obviously the 8 per cent. would be higher were the percentage for cooking less than he actually shows. May I suggest to the members the lesson indicated by one of the graphs, showing the lighting load after 12 o'clock to dawn. You will notice from the graph that the proportion of gas used for lighting is very considerable. That, of course, is mostly public lighting, and were we to lose that custom we should be sending out little or no gas during those hours. That would be a most unfortunate thing for our undertakings, and the lesson I draw from the graph is this, that the custom possible between 12 o'clock and dawn, which is practically all public lighting, points to the desirability of supplying this gas for public lighting at as low a figure as possible. In other words, we are able to supply gas for public lighting purposes during those hours at a lower price than we do ordinarily at the present time.

My remarks have been general, but I am glad to have heard this paper, and I am sure it will be of great interest to us all.

The President: With regard to what Mr. Watson said at the commencement of his speech, I should like to make it clear that I do not wish to debar any member from expressing his thanks to the reader of a paper, especially if he follows the admirable example of brevity set by Mr. Watson. I do feel, on the other hand, that far from curtailing our thanks, we owe a very deep debt of gratitude to all those reading papers, and I do not wish in any way to curtail our thanks, provided we do not occupy time thereby which might be better devoted to the discussion of the papers. After all, sufficient discussion of a paper is the most practical way, as I said before, of showing our gratitude

to the readers. If there are not others who would like to join in the discussion, I will call on Dr. Thomas to reply.

Dr. THOMAS: I can only say that in a way I am disappointed. I have never read a paper on statistical matters in any meeting, other than this one, at which someone in the audience has not said that there are three kinds of lies—a lie, a damned lie, and statistics. [Laughter.] The matter I have dealt with in the paper, however, does not belong to any of those categories; I believe these statements are actual facts. I have dealt with the matters as reasonably as I can, and I believe the figures I have got out are actual facts, and not even statistics. [Laughter.] I should like to thank all the speakers for their very kind remarks. As I have said already, any merit the paper has is largely due to Dr. Carpenter's very kind interest in this matter, and your thanks are due to him and not to me.

I will endeavour to deal seriatim with the different points that have arisen. Mr. Lacey has used something very much like this method, so he tells me. I have seen some of his curves, and they are most interesting. Very interesting matter would be derived from a comparison of the output curves of the South Metropolitan Gas Company and those of the Gas Light and Coke Company. Dr. Carpenter made reference to a comparison of a pair of these curves in his paper read before the Institution in 1921. A comparison of the different curves of the different companies provides a great deal of material for discussion by the Institution. Mr. Lacey also brought up the point, and quite rightly, as to the two different methods of correction applied in the paper. The essence of the whole matter is this. The first thing I tried to get out was the lighting load. I got the lighting load out first of all, and it was only afterwards that I found that by taking the lighting load off these different curves, the two curves are superposable. If you take the lighting load off any day's curve—you can take a day in March, August, September, or any other month you like—you can put these curves so that they fit practically on top of one another for the greater part of their length. It was then that I spotted how the heating load was to be determined, and, with regard to Mr. Lacey's remark that I had used two different methods of correcting the load curves, the difference only amounts to something of the order of 0·1 per cent. The first method is the simpler one. It does not want long mathematical symbols which frighten people who apply the thing. I have been anxious to get something in the paper that will be used; I really hope the method will be used by the industry. There is no need to frighten the industry at all in this; it is straightforward work. It is not something like that which happened to the Duke of Wellington in one of his Peninsular campaigns, when he was short of Officers. An urgent message was sent home, and the authorities here sent out to him every man available, every slab-footed, hump-backed man they could get hold of. When these men got to the front, Wellington paraded them and said to his Aide-de-Camp, "I don't know what the effect on the enemy is going to be, but, by God, they frighten me." [Laughter.] I do not wish to put anything in the paper that will frighten the gas engineers, because I am most anxious that gas engineers should use the method which I have developed here, and that is why I leave the first part as it is, because I can assure you that the necessary corrections are only something of the order of 0·1 per cent.

The lighting load of the South Metropolitan Gas Company comes out at something between 16 and 17 per cent. all over the year, and I consider that a very good load. Dr. Carpenter pointed out to me—we must remember that South London is not a very wealthy district—that this percentage corresponds to about one lighting burner per consumer, and that is very reasonable. You have the human aspect of that. In many cases all the family are crowded into one room, generally the kitchen, and the burners in the other rooms may be used only during the week-end, or perhaps there is a burner on the landing or in the hall. These are only used on "posh" occasions, when the daughter's young man comes at the week-end, or something of that kind, so that it amounts to every consumer using one lighting burner.

I am very much indebted to Mr. Butterfield for coming here and making such appreciative remarks of the little effort that I have put into the paper. Mr. Butterfield, of course, we all know, is a great advocate of the retention of the lighting load, but I would like to say that the lighting load will only be retained, in my opinion, by the provision of very much better lighting appliances than are supplied to-day even by the Gas Industry. That is my candid opinion. Apart from being in the Gas Industry, I would be absolutely ashamed of a great many of the lighting burners that are provided even by gas companies to-day. The Gas Industry itself is losing the lighting load; some of the burners which I have seen recently might easily be labelled "Found in the trenches," or something of that kind. They are really abominable, but they are used, and it is up to the Gas Industry to put its own house in order with regard to the lighting load, because the lighting load can be retained quite easily. In this connection I should like to point out to the Gas Industry generally that it is impossible to go into Woolworth's and buy a bad electrical fitting.

I am very appreciative of the remarks of Mr. Watson. We have worked together on the Joint Lighting Committee of this Institution, and the thing the Gas Industry has to do is to make up its mind about the lighting load. Does the industry want to retain the lighting load, or does it want to develop the industrial load? I do not think the industry has yet made up its mind on this matter. I read the Technical Journals of the Gas Industry, and I do not think the industry has really made up its mind as to which load it wants to retain and which load it wants to lose. The position is very much like that which once happened in New York, where one came across a striker, during the days of strikes, and somebody asked him: "What is all this fuss about?" The striker answered: "I don't know what we want, but, by God, we want it very badly, and we want it very quick" [Laughter.] The state of affairs with regard to lighting in the Gas Industry strikes me, as an outside observer, as being very much like that, and we have got to make up our minds what we want to do in the industry. I am perfectly certain the industry can retain or develop the load that it desires to, because, after all, gas is the perfect fuel.

The PRESIDENT: I have already thanked Dr. Thomas for his paper, but I am sure I shall be carrying out your wishes if I thank him again for his most admirable reply. [Applause.]

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The Results of Constructive Policy as Applied to a Small Gas Undertaking

By W. CLARK JACKSON, M.Inst.Gas E., A.M.I.Mech.E.,

Engineer and Manager, Neath Corporation Gas Department

INTRODUCTION.

In presenting this Paper I feel that I am going over ground that has been covered before by other Engineers, and with probably better results than I have been able to obtain at Neath; but our President persuaded me to give a Paper upon these lines, and I have, therefore, prepared notes and figures covering the reconstruction work carried out by the Neath Corporation Gas Undertaking during the past eleven years.

When I took charge of the Neath Undertaking in May, 1915, I found that a considerable amount of reconstruction work was urgently essential to put the Undertaking on a sound basis, both with regard to the manufacture and distribution of Gas, and in the matter of finance and administration. Unfortunately, it was found impossible to carry out any reconstruction work during the War years, with the exception of the installation of a 400,000 c.ft. per day capacity Carburetted Water Gas Plant, together with two Water Tube Boilers, for which the Department was fortunate enough to obtain the necessary permits. The inclusive cost of this plant was £3733. This eased the position so far as the production of Gas was concerned and enabled the Undertaking to carry on during the latter years of the War with some measure of security.

In the early part of 1919 the question of reconstruction was gone into very carefully and it was decided to proceed in the following stages:—

(1) To put down modern carbonizing plant of an adequate size, so as to ensure the supply to consumers of a steady quality of gas.
(2) To lay down a series of new feeder mains from the Works to the district, in order to ensure an adequate pressure of gas to consumers.
(3) To overhaul thoroughly the old existing mains, together with consumers' services and meters, for the purpose of reducing the Unaccounted-for gas, which at that time stood at 21·1 per cent.
(4) To overhaul generally and to put into good repair the buildings and equipment at the Works.
(5) To replace the Condensers and the Wet Purification Plant, which were even then of an inadequate capacity.

Coincident with this programme it was decided to introduce a progressive Selling Policy, together with a Maintenance Service calculated to gain the confidence of the consumers, and generally to reorganize the whole commercial side of the Undertaking so as to put it on a modern basis.

Table I. below shows the general position of the Department at this time:—

TABLE I.—*Statistics for the Neath Corporation Gas Department on the 1st April, 1919.*

Make of gas per annum	121,832,000 c.ft.
Sale of gas per annum	96,126,000 ,,
Leakage and unaccounted-for gas	21·1 p.c.
Price of gas	5s. per 1000 c.ft., or 14·11d. per therm
Outstanding capital to be repaid by the undertaking on loans raised for plant, mains, &c.	£23,066
Outstanding capital per 1,000,000 c.ft. gas made	£190
Outstanding capital per 1,000,000 c.ft. gas sold	£240
Bank overdraft	£17,897

I. REORGANIZATION—FIRST PHASE: 1921-1928.

COMMENCEMENT OF RECONSTRUCTION.

Vertical Retorts.

Proceeding with the programme, as outlined in the Introduction, a contract was entered into with the Woodall-Duckham Vertical Retort Company for the installation of Vertical Retorts of a nominal capacity of 750 thousand c.ft. per day, this capacity being decided upon in view of the fact that it was anticipated that the Neath Borough and the Briton Ferry Urban District Council would probably amalgamate in the near future, and that this would mean the taking over by the Neath Corporation of the Briton Ferry Urban District Council's Gas Undertaking.

The Contract Price for this Plant was £36,589, but owing to the extreme variations in the price of material at that time, the actual cost of the installation, including foundation work and dismantling of old material and excavations, was £41,226. The plant was put to work on July 14th, 1921, and provided a very excellent commencement of our policy of reconstruction.

Feeder Main.

Later on in the year a new Feeder Main of 16 in. down to 10 in. pipes was laid down and carried beyond the centre of the town, and from this all the various subsidiary feeding mains to the district were taken off. The cost of this work amounted to £1881.

MAINTENANCE SERVICE.

Towards the end of the year 1921 a system of Maintenance Service was also put into operation, this service being exceptional in that the staff employed consisted of women specially trained for the work.

Staff.

Five Lady Inspectors are now employed, each of whom visits, on an average, twenty-seven houses per day. This entails an average period of about eight weeks between each inspection.

Training of Inspectors.

Each Inspector receives the following instructional courses before commencing her duties:—

(i) Three months in Fitting and Cooker Repairing Shops, with intensive training in the repairing, regulating, and adjusting of gas cookers, gas fires, burners, &c.
(ii) Specialized training with Chief Maintenance Inspector for three months.

Attendance for two years at Winter Courses of Cookery Classes is also required for the purpose of enabling them to be of additional service to housewives in the matter of cooking.

Duties of Inspectors.

The duties of Inspectors can be summarized as follows:—

(i) Regulation of lights, adjustment, and regulation of cookers, gas fires, water heaters, irons, &c.
(ii) Special complaints of leakages or defects which require the services of a gas fitter are reported to the Office on the morning following the visit of inspection and receive immediate attention.
(iii) Inspectors are also instructed to report any apparatus which appears to be defective or out of date, and these reports are followed up by the District Superintendent.

Receipts.

Inspectors carry receipt books with them, and the work is dealt with on a strict cash basis. Special arrangements for credit are made with large or special consumers.

Check.

The usual check is kept on these Inspectors by special

" follow-ups " made by the Superintendent and by letters from the Office inquiring as to the satisfaction of the services to the consumer. There is also an internal check on the material taken by them from stores.

Cost.

No charge is made for this maintenance service, the consumer paying only for material used and for goods purchased. The cost of this service to the Department, after giving credit for profit on sales made by the Inspectors, works out at ·41d. per 1000 c.ft. of Gas sold.

Results of Reorganization.

Statistical.

The effect of the improved gas supply, *plus* the Maintenance Service, soon made itself felt in an increased demand for gas, and from this date forward the Department has registered a steady increase year by year, even during these latter few years when the South Wales District has been under the shadow of deep industrial depression. This increase is shown in graph form in the Appendix,* where Chart 1 illustrates the increase in the number of consumers and in the consumption per head. In Chart 2 the increase in the make from 122 millions for the year to 31st March, 1919, to 236 millions for the year to 31st March, 1932, is recorded. Fifty millions of this increase was taken over from the Briton Ferry undertaking on 1st November, 1923. The same chart, No. 2, records the corresponding increase in sales from 96 millions to 213 millions.

At the same time the financial results showed a remarkable improvement, and enabled the price of gas to be reduced. Fluctuations of price are shown in Chart 3 of the Appendix, which sets out the price at which gas has been sold from 1st April, 1919, to 31st March, 1932, and illustrates that, apart from a temporary increase in 1926, due to strike conditions, there has been a steady reduction, the highest price during the period being 18·30d. per therm, and the lowest, which is now ruling, being 10·59d. per therm. Similarly the Bank Overdraft, which in 1919 was £17,897, and which on 31st March, 1922, reached £19,886, had been reduced by the 31st March, 1932, to £2116.

During the year to 31st March, 1923, a serious attempt was made to bring down Unaccounted-for Gas, and as a result of these efforts a reduction of nearly 4 per cent. was obtained at a cost of about £2000 for work on Mains, &c. Chart 4 of the Appendix shows the Unaccounted-for Gas as a percentage of the Make for the period 1st April, 1918, to 31st March, 1932. The reduction of this percentage to 9·7 per cent. for the year to 31st March, 1927, is due to the General Strike period, when District Pressures were reduced for seven months. For the period under review, a reduction from 21·1 per cent. to 9·7 per cent. will be noted.

Chart 5 shows the Mileage of Mains. The comparatively large increase shown as having taken place during the year to 30th March, 1925, is accounted for by the taking over of the Briton Ferry Undertaking, whose mains at that time totalled 9·5 miles. Apart from this, the increase in the mileage has been of a fairly steady character.

Constructional.

Extension of Area of Supply.

In 1923 the extension of the Neath Borough to incorporate the Briton Ferry Urban District Council's area and Gas Undertaking was brought about, but for the time being it was decided to run the two Gas Departments as separate units. In the early part of 1924 it was decided to proceed with the laying down of a trunk main from the Neath Works to Briton Ferry for the purpose of enabling the Briton Ferry Works to be closed down as a manufacturing centre, and this work was done during the Spring and Summer months. The cost of this work was £5861, being:—

	£
New mains, including 10 in., 8 in., and all connections .	3269
Labour	2592
	£5861

The Briton Ferry Works were closed down on 14th October, 1924, and the supply of gas to this district from the Neath Works commenced. To provide for the cost of this main a loan of £6000 had been raised, and this necessitated an additional annual sum of £600 being provided out of profits for Repayment of Loan and Interest. During the subsequent twelve months the benefits accruing from the closing down of the Briton Ferry Works as a manufacturing centre give a gross saving of £2250, and, therefore, a net saving of £1650 per annum.

New Holder and Repairs.

The question of holder storage was now investigated, as the smaller of the two holders having a storage capacity of 250,000 c.ft. had been utilized as a relief holder for the Carburetted Water Gas Plant since 1917 and this left but one holder at Neath to take the Make Gas. It was decided, therefore, to install a new and separate relief holder of 100,000 c.ft. capacity, so as to enable the holder of 250,000 c.ft. capacity to be put back into commission as an ordinary purified gas storage holder and thereby to increase the storage capacity at the Neath Works from 375,000 c.ft. to 725,000 c.ft. This, with the two holders at Briton Ferry, one of 250,000 c.ft. capacity and one of 80,000 c.ft. capacity, gave a combined storage of 1,055,000 c.ft.

The cost of this new holder, complete with foundations, was £3750.

During the year to the 31st March, 1923, the whole of the buildings at the works were re-roofed, the gasholders were examined carefully and repaired, and an effort was made to improve the general condition of the works and plant, £3146 being spent on this work.

New Stores System.

A new Stores System was brought into operation, and the latest modern methods of keeping records of stocks, &c., were adopted. The saving in material at the end of the first year's working under this new system amounted to approximately £350, and proved that considerable leakage had been taking place previously.

Price of Gas.

The year 1926 will be remembered by reason of the protracted Coal Stoppage, and this caused an increased expenditure of £5300 on coal during the strike months. Although it was felt that this should be covered by an increase in the price of gas, it was decided that it would be better in the best interests of the community to carry on without an increase. The following resolution was passed by the Gas Committee:—

> " That this Committee having considered the Manager's report, whilst agreeing that the recommendation of the Manager was fully justified, do not, however, consider that the present is an opportune time to increase the price of gas, having regard to the recent increase in the Neath Rates and added hardships which an increase in the price of gas would effect."

This resolution shows very clearly the difference between the policy of a Municipally-owned Undertaking and that of a Company-owned Undertaking.

As this meant that the Department would suffer a very great set-back financially, the Author continued to press for a small increase, and eventually was able to persuade the Gas Committee to authorize an increase of 4·25d. per 1000 c.ft., or ·98d. per therm. Unfortunately, this was only allowed to operate for a few months (see Chart 3 of the Appendix). The financial position of the Undertaking, therefore, did actually suffer a considerable reverse. Chart 6 of the Appendix gives particulars of the Gas Department's overdraft at the Bank, covering the years under review, and the effects of the strike period are clearly illustrated.

New Showrooms.

In 1927 consideration was given by the Committee to the question of opening new showrooms at Neath and Briton Ferry. It was decided to concentrate on Briton Ferry, as there was already a small showroom at Neath, and suitable premises were obtained, fitted out, and formally opened in May, 1928.

* The actual charts are not reproduced in this number of the " JOURNAL," but the stages of development are clearly seen from the tabulated figures in our Appendix.—ED. " G.J."

II. REORGANIZATION—SECOND PHASE: 1928-1932.

Reconstruction.

New Plant.

In 1928 it was decided to proceed with the installation of the new Condensers and Washer Scrubber and of a new Station Meter and Dri-Gas and Naphthalene Washer. Tenders were invited and contracts for the plant placed as follows:—

Water-cooled condensers —Horizontal tube type . .	1½ million c.ft. per day. Clapham Brothers, Limited Keighley. Contract price, £995. Plant put into operation, December, 1928.
Washer scrubber	1½ million c.ft. capacity. W. C. Holmes and Co., Ltd., Huddersfield. Contract price, £950. Plant put into operation, February, 1929.
"Connersville" station meter .	60,000 c.ft. per hour capacity. W. C. Holmes and Co., Ltd., Huddersfield. Contract price, £386. Plant put into operation, May, 1929.
Dri-gas and naphthalene washer	1½ million c.ft. per day capacity. W. C. Holmes and Co., Ltd., Huddersfield. Price, £1600. Plant put into operation, May, 1929.
Foundations, connections, &c. .	£650.
Total	£4581.

New Showrooms.

During this time negotiations were being conducted with a view to obtaining suitable premises for a new Showroom at Neath; these were eventually obtained and the work of re-designing the premises was put in hand. These new showrooms were opened in June, 1929, and completed the original programme of work.

Results of Reconstruction.

Dri-Gas and Naphthalene Washer.

The Dri-Gas and Naphthalene Washer has given excellent results, and in addition to the very much improved service rendered possible to the consumers, owing to the freedom from stoppages due to moisture and naphthalene deposits, has effected a considerable saving in the cost of handling of consumers' complaints. The plant has worked continuously since it was put into use, with entire freedom from trouble.

TABLE II.—*Cost of Dealing with Consumers' Complaints due to Naphthalene, Rust, and Water Condensation, and the Pumping of District Syphons Before and After the Installation of a Dri-Gas and Naphthalene Washer.*

Capacity of plant . . . . . 1½ million c.ft. per day
Contract price £1600
Installed and put to work . . . 28th May, 1929

—	Twelve Months Ended—		
	28th May, 1929	28th May, 1930.	31 March, 1932.
	£ s. d.	£ s. d.	£ s. d.
Cost of attending to public lamp complaints due to naphthalene	35 17 4	15 12 0	0 7 6
Cost of attending to public lamp complaints due to rust. . .	41 13 6	4 14 0	1 17 4
Cost of attending to district syphons	50 17 4	9 19 6	1 14 0
Cost of attending to consumers' complaints found to be due to water condensation . . .	204 0 0	..	..
Cost of attending to consumers' complaints found to be due to naphthalene	334 18 0	21 5 0	..
Cost of attending to consumers' complaints found to be due to rust	321 4 0	161 0 9	113 2 0
Total cost	£988 10 2	£211 11 3	£117 0 10

Table II. above is a statement of the annual cost of dealing with consumers' complaints due to Naphthalene Rust and Water Condensation and of the Pumping of District Syphons before and after the installation of a Dri-Gas and Naphthalene Washer.

Table III. shows the cost of operating a Dri-Gas and Naphthalene Washer, including capital charges (Loan Repayment and Interest), wages, calcium, steam, oil, &c.

TABLE III.—*Cost of Operating Dri-Gas and Naphthalene Washer, Including Capital Charges (Loan Repayment and Interest), Wages, Calcium, Steam, Oil, &c.*

Capacity of plant . . . . . 1½ million c.ft. per day
Contract price £1600
Installed and put to work . . . 28th May, 1929

—	Twelve Months Ended—	
	28th May, 1930.	31st March, 1932.
	£ s. d.	£ s. d.
Capital charges (dri-gas section, including loan repayment and interest), wages, steam, oil, &c.	91 15 2	83 5 2
Capital charges (naphthalene section, including loan repayment and interest), wages, steam, handling of oil, &c.	82 15 0	82 15 0
Total cost	£174 10 2	£166 0 2

Table IV. below, using the results of Tables II. and III., shows the approximate annual savings effected by the installation of a Dri-Gas and Naphthalene Washer.

TABLE IV.—*Annual Savings Effected by the Installation of Dri-Gas and Naphthalene Washers.*

Capacity of plant . . . . . 1½ million c.ft. per day
Contract price £1600
Installed and put to work . . . 28th May, 1929

—	Twelve Months Ended—	
	28th May, 1930.	31st March, 1932.
	£ s. d.	£ s. d.
Cost of consumers' complaints—		
Twelve months previous to installation	988 10 2	988 10 2
Twelve months to date	211 11 3	117 0 10
	776 18 11	871 9 4
Less cost of operating . . .	174 10 2	166 0 2
Saving for the year	£602 8 9	£705 9 2

The saving for the year to 31st March, 1932, is equivalent to 0·83 pence per 1000 c.ft.

Mains and Services.

As no internal corrosion of mains and services is now taking place, a considerable further saving may be taken into account in respect of their longer life.

Meters.

Inspection of selected meters from various parts of the district shows that the condition of the leather diaphragms and mechanisms is practically as good to-day as when the meters were new, and although it is only fair to allow a longer period for test before dogmatizing upon this point it would appear probable that meter repair costs will be reduced considerably in the future as a result of the working of this plant.

Benefits from the Dri-Gas and Naphthalene Washer.

The results which can be expected from the installation of a Dri-Gas Naphthalene Washer can be summarized:

(*a*) A very considerable reduction in distribution costs due to the prevention of internal corrosion of mains and services.
(*b*) Entire freedom from pumping of district syphons and from having to dispose of condensates and water, which so often are of a very foul-smelling character.
(*c*) An ability to guarantee to consumers a practically uninterrupted supply of gas.
(*d*) A much greater ease in locating leakages of gas, as any water found to exist on the distribution system points at once to a leakage of gas in its immediate vicinity.
(*e*) A reduction in the cost of upkeep and repairs of meters.
(*f*) Longer life of service pipes and mains.
(*g*) Much fewer road openings by the Gas Undertaking —a matter very much appreciated by the engineering staff of any Corporation in these days of intensive road traffic.

By supplying trouble-free gas a very great step forward is made towards the ideal—of giving real service to consumers.

Condensers and Washer Scrubber.

With the putting into operation of the new Condensers and new Washer Scrubber, trouble was experienced with tar fog passing forward to the Purifiers. The old Washer Scrubber, which was of the tower design, had apparently acted not only as an Ammonia Washer, but also to a great extent as an extractor of tar fog, no doubt due to the tar which had accumulated on the wood boards acting as a means of entraining tar fog. Efforts were made to free the gas from tar fog by altering the Livesey Washer and by utilizing a weak liquor flow in the first half of the washer scrubber, but without any real success. It has been found necessary, therefore, to put down a P. & A. Tar Extractor, and although traces of tar fog still show at the outlet of this machine the percentage is so small as not to affect the working of the Purifiers or the condition of the oxide. The cost of the P. & A. Tar Extractor was £249.

Reduced Price of Gas.

It was now found possible to reduce further and substantially the price of gas and this reduction, with the improved service given to consumers, created an increased demand, in spite of the period of depression which was being experienced in the South Wales District generally. The ability to give a steady quality of gas at a reasonable pressure and free from irritating interruptions, together with the Maintenance Service which had now been further developed to include the inspection and putting into order of every gas fire, cooker, and gas-heated apparatus in use on the district, with new Showrooms at Neath and Briton Ferry, had a definite and marked effect on the demand.

GAS LIGHTING.

Public Lighting.

During the time that all these various improvements had been carried out and more particularly from round about 1926, Public Lighting received the careful attention of the Department, and the whole of the lamps on the main thoroughfares were taken down and replaced by new lamps of increased Candle Power and higher efficiency. The type of lamps substituted in the centre of the town were of the " Littleton " pattern, the candle power varying from 900 c.p. to 500 c.p.; for the throughway streets lamps of the " Promenade " type of 400 c.p. were utilized. This replacement has proved of considerable advertising value to the Department, and it is interesting to note that within the last twelve months the Department has been successful in obtaining the contract for the lighting of a new 'Bus Centre, the installation consisting of fourteen 400 c.p. " Rochester " Lamps and one 900 c.p. " Rochester " Lamp, all fitted with directional reflectors.

The Lighting of Private Houses.

With regard to the supply of gas to Municipally-owned Housing Estates, it is interesting to note that at Neath, where the Electricity and Gas Departments are both owned by the Municipality, the Gas Department has been successful in retaining the use of gas in each of the 370 new houses which have been erected at Neath and Briton Ferry. In every case gas is supplied for lighting as well as for cooker, wash-boiler, and one gas fire. In addition, when fitting the last fifty of these houses, the Gas Department included at its own expense one Lighting Switch in each of the houses, for the purpose of bringing gas switching to the attention of the Housing Committee.

III. CONSOLIDATION.

TRAINING OF OUTDOOR AND SELLING STAFF.

By the year 1929-30 the position of the Undertaking had been consolidated, and the question then arose as to the best means of developing still further the Sales of gas within the district. It was decided that a scheme of more intensive training of the Outdoor and Selling Staffs of the Department, together with intensive local advertising, should be initiated.

Arrangements were made, therefore, for Lectures to be given to the Outdoor and Selling Staffs at monthly intervals during the winter, commencing in October and completing the course in the following May. This has been regularly carried out, and lectures covering the construction, correct fitting and efficient utilization of all types of gas-using apparatus have been given. These lectures have considerably widened the views of the individual members of the Staffs concerned, and, apart from the greater efficiency obtained in their own particular line and as selling agents for the Department, have developed the ideal of " Gas for Service " which I have made, at these lectures and in all the Department's advertising, the continued slogan of the Department.

ADVERTISING CAMPAIGN.

A considerable sum of money has been spent by the Department on advertising campaigns, but as has been found by other Undertakings and Concerns which have developed intensive advertising, together with an improved Sales Policy, the cost has been repaid more than one hundredfold. Not only so, but it has brought about a feeling on the part of the Public in the Neath District that the Gas Department is progressive, alive to its obligations, and can be depended upon to give efficient service at all times. Chart 7 of the Appendix clearly shows the effect of this policy on the Hire Purchase Sales of Cookers and Fittings, which increased in value during the period from £1223 to £5282. Chart 8 shows the increase in the Balance due on Hire Purchase Sales of Cookers and Fittings.

SLOT CONSUMERS—SALES AGAINST REBATE MONIES.

At this period consideration was also given to the question of increasing Fittings Sales amongst the Department's Slot Consumers which at this time were not entirely satisfactory, probably due to their being dealt with on a strict cash basis. It was decided to inaugurate a Slot Rebate Sales System, whereby the initial payment in respect of any Appliance or Fitting sold would be as low as possible and to allow for the balance of payment to be made from the rebate monies due to the slot consumers at each collection. The extent of this rebate was and still is 4d. per 1000 c.ft.

It is interesting to note the extent of the business which has been developed following upon this Policy and which is shown in graph form on Graph 9 of the Appendix. The number of slot consumers using rebate sales has increased from 98 on the 1st April, 1930, to 486 on the 31st March, 1932, while the value of the annual sales out of Rebate during the same period increased from £56 to £310.

SALES POLICY—MAINTENANCE *versus* CANVASSING.

The Author feels compelled to emphasize again the beneficial effects of the Maintenance Scheme as operated at Neath upon the general question of sales of fittings, appliances, &c.

In his opinion, the confidence which has been built up between the consumer and these Lady Maintenance Inspectors is such that recommendations made by them and which are all made following upon some definite selling policy, receive much more careful consideration than would be the case if this work of selling additional appliances was carried out by the usual type of canvasser salesmen.

INDUSTRIAL SALES.

The question of developing Industrial Sales of Gas was also considered, and attempts were made to open up a field for this service in the local Tinplate, Steel Sheet, and Tinplate Decorating Works. Special surveys were made of the different methods of firing and heating in use at those various works, but unfortunately there was a considerable amount of prejudice against new ideas, especially where firing and heating were concerned. It was decided, therefore, that it would be necessary to carry out an educational campaign amongst these various works before there could be any likelihood of getting an opportunity of putting in hand even experimental work.

Following up this policy, every opportunity was taken of keeping the various Industrial Works informed of the developments in the use of gas for Industrial purposes which were taking place in various parts of the country, and in addition literature which had been obtained from

America and which dealt with the application of gas for industrial purposes was circulated.

It was not, however, until August, 1931, that the efforts really bore fruit.

For use in the various campaigns prices for gas for industrial purposes had been computed, and had been resolved back into estimated firing and heating costs competitive with coal, coke, and oil.

In August, 1931, the Department was approached by one of the local Tinplate Companies, with which it had been in touch from time to time and which had introduced gas-firing in its works using Anthracite Gas for this purpose, to see whether a definite proposal with regard to the utilization of Town's Gas at one of their other and smaller works could be made. It was promised that if the Company could be convinced that the all-in costs using Town's Gas would not be greater than the all-in costs using coal they would be prepared to give the Department an opportunity of carrying out experiments. This opportunity of showing what could be done was appreciated, and after further negotiations an arrangement was made to carry out this experiment for a minimum period of three months, a period which would be extended if the experiment showed signs of being successful.

The experimental work proved successful and the question arose as to the enormous load which was likely to be developed within the Department's district of supply. This load was likely to exceed all original estimates, and indicated that very large extensions to Works Plant and the laying down of a considerable amount of new High Pressure Mains, Boosting equipment, &c., would be necessary.

Fortunately, just at this time the Department was approached by the Anglo-Persian Oil Company to see whether it would be prepared to utilize a certain amount of gas which the Anglo-Persian Oil Company had for disposal. This particular gas was of Calorific Value of about 1550 B.Th.U. per c.ft., and it was suggested that it could be utilized as a means of enriching blue water gas, thereby dispensing with the use of Gas Oil. The Anglo-Persian Oil Company could make it possible for a considerable amount of this gas, commencing with at least 50,000 c.ft. per hour, to be placed at the service of the Gas Department. It was realized that in addition to utilizing this gas for the purpose for which the Department had been approached it might be possible for this gas to be utilized purely and simply for Industrial purposes, and thereby save the Undertaking from having to go in for the proposed large extension work.

* Full details of the experimental work carried out and the results obtained were given by the author in a paper read before the South Wales Branch of the Mechanical Engineers at Swansea on Tuesday, 12th April, 1932.

At the time of writing this paper it is too early to give details of the experimental work carried out upon the utilization of this Oil Gas in the Tinplate Industry, but preliminary experiments proved that the gas could be efficiently used, and in fact the Company for whom the Department has been carrying out these tests was so impressed with these preliminary experiments as applied to its tinpot heating that orders were immediately given to the Department to proceed with the conversion of one set of its Mill Roll Furnaces from coal-firing to firing by means of this gas.

The ultimate business likely to be obtained as an Industrial Load within the Neath District would appear to be in the region of 250 million c.ft. per annum, or practically equal to the output of the Undertaking for its ordinary Domestic and Heating Business.

Position on 31st March, 1932.

At the end of March, 1932, the position of the Undertaking was as follows:

Table V.—*Statistics of the Neath Corporation Gas Department on the 31st March, 1932.*

Make of gas per annum	235,682,000 c.ft.
Sale of gas per annum	212,821,000 ,,
Leakage and unaccounted-for gas	9·7 per cent.
Price of gas	3s. 9d. per 1000 c ft., or 10·588d. per therm
Outstanding capital to be repaid by the undertaking on loans raised for plant, mains, &c.	£63,216
Outstanding capital per 1,000,000 c.ft. of gas made	£272
Outstanding capital per 1,000,000 c.ft. of gas sold	£297
Bank overdraft	£2116

CONCLUSIONS.

It will have been gathered that the Author possesses a very great faith in the Gas Industry, not only with regard to its present usefulness to the Nation, but to its ever-increasing future usefulness; and it is suggested that there is room within the Industry for a great deal more of this optimism based upon a strong faith in the merits of Gas and supported by a progressive or even aggressive policy of administration built up upon modern ideas of Service to the Consumer.

An endeavour has been made to show that for even a small Gas Undertaking—provided its Administrators are prepared to give careful consideration to the adoption of a constructive policy suited to its own district and are prepared to follow this through in a capable and wise manner—the business likely to be obtained will more than repay the efforts and worries attached to the pursuance of such a policy. Furthermore, a great deal will have been done to maintain the good name of Gas, and this in itself will react in a beneficial manner throughout the whole Industry.

APPENDIX.

(A) *Number of Consumers.*

31st March.	Consumers.
1919 ..	5100
1920 ..	5160
1921 ..	5201
1922 ..	5275
1923 ..	5350
1924 ..	6900
1925 ..	7010
1926 ..	7270
1927 ..	7454
1928 ..	7648
1929 ..	7768
1930 ..	8105
1931 ..	8217
1932 ..	8335

Table 1.

(B) *Consumption per Consumer.*

Year to 31st March.	C.Ft.
1919 ..	18,800
1920 ..	20,800
1921 ..	18,800
1922 ..	20,400
1923 ..	21,000
1924 ..	23,600
1925 ..	23,600
1926 ..	23,900
1927 ..	23,600
1928 ..	24,200
1929 ..	24,800
1930 ..	24,800
1931 ..	24,800
1932 ..	25,500

Annual Make and Sales.

Year to 31st March.	Make in Millions of C.Ft.	Annual Sales in Millions of C.Ft.
1919.	121·83	96·13
1920.	134·77	107·68
1921.	119·98	98·27
1922.	132·09	108·05
1923.	131·30	112·52
1924*	189·48*	162·96*
1925	193·99	166·83
1926.	202·81	174·22
1927.	195·51	176·59
1928.	209·08	185·66
1929.	217·54	193·39
1930.	227·00	201·58
1931.	229·40	204·44
1932.	235·68	212·82

* The figures for 1924 include for the first time the make—50·43 million c ft.—and sales of the Briton Ferry undertaking, which was added on 1st November, 1923.

Table 2.

Price Changes.

To Pence per Therm. d.	Date of Change.
14·11	
15·53	1st April, 1920
18·30	1st July, 1920
15·59	1st October, 1922
13·48	1st April, 1924
12·50	1st April, 1925
13·48	1st October, 1926
12·50	1st July, 1927
11·06	1st April, 1928
10·59	1st July, 1929

Table 3.

APPENDIX—*Continued.*

Unaccounted-for Gas.

Year to 31st March.	Percentage of Annual Make.
1919	21·1
1920	20·1
1921	18·1
1922	18·2
1923	14·3
1924	14·0
1925	13·9
1926	14·1
1927*	9·6*
1928	11·2
1929	11·1
1930	11·2
1931	11·0
1932	9·7

TABLE 4.

Mileage of Mains.

31st March.	Mileage Mains.
1919	26·25
1920	27·0
1921	28·0
1922	28·5
1923	29·5
1924*	40·0*
1925	40·75
1926	41·5
1927	42·33
1928	43·0
1929	43·25
1930	43·5
1931	43·75
1932	44·5

* The amalgamation with the Briton Ferry Undertaking on 1st November, 1923, added 9¼ miles.

TABLE 5.

Bank Overdraft.

31st March.	Overdraft. £
1919	17,897
1920	12,783
1921	19,039
1922	19,886
1923	17,035
1924	16,181
1925	7,143
1926	5,556
1927	6,165
1928	3,109
1929	1,147
1930	518
1931	1,986
1932	2,116

TABLE 6.

Hire-Purchase Sales of Cookers and Fittings.

Year to 31st March.	Total of Annual Hire Purchase Sales. £
1919	1223
1920	2435
1921	2580
1922	4110
1923	2735
1924	2621
1925	3513
1926	4381
1927	4189
1928	4360
1929	4280
1930	4306
1931	4435
1932	5282

TABLE 7.

Balance due on Hire-Purchase Sales of Cookers and Fittings.

31st March.	Balance Due. £
1919	78
1920	142
1921	190
1922	240
1923	290
1924	427
1925	788
1926	974
1927	1021
1928	1140
1929	1263
1930	1344
1931	1429
1932	1739

TABLE 8.

(A) *Consumers using Rebate Sales.*

31st March.	Number of Consumers.
1930.	98
1931.	366
1932.	486

(B) *Annual Sales out of Rebate.*

Year to 31st March.	Annual Sales. £
1930.	56
1931.	246
1932.	310

TABLE 9.

DISCUSSION.

The PRESIDENT: Those of us who are colleagues of Mr. Jackson in South Wales have long been aware of the steady constructive, or perhaps I should say reconstructive, policy, which has been applied by him so successfully over a considerable period, and it occurred to me that a record of his experiences would be valuable to this Institution, and particularly to those who are in charge of moderate sized works. With this end in view I asked him to prepare this record and put it before you as a paper, and I should like to express in the first place my personal thanks to him for the ready and prompt and very able manner in which he has carried out that request. I should like in the next place to thank him on behalf of the members of the Institution for this valuable contribution to their Transactions, and I sincerely trust that the volume and nature of the discussion will also prove that you are grateful to him for the production of this paper.

VALUE OF PUBLIC STREET LIGHTING.

Mr. H. D. MADDEN (Cardiff): I have been asked to open this discussion probably because Mr. Jackson is a member of our District Association—the Wales and Monmouthshire. I have been closely in touch for years with what he has been doing at Neath and the great advances the Neath Corporation has made in its gas lighting. I would also like to refer to one thing in this connection. When it was mooted by the National Gas Council that a laboratory and showroom for industrial gas should be initiated for the area and placed at Cardiff, Mr. Jackson recommended his Committee to support it; and his Council, together with your President, were the first to rally to my Company, and they have done a great deal to make that showroom and industrial laboratory a success. I notice that Mr. Jackson refers to the value of public street lighting and we cannot too often reiterate that point. If you look at the percentage of revenue from street lighting, it is not very much. It is a small percentage; but it is the mentality of the man in the street which is of such importance. If you can keep the lighting in the streets and in the homes of the people you undoubtedly get much more gas demanded for other purposes. In cottage homes, in which in this country two-thirds of the population lives, gas lighting is the most efficient and most economical, and I think, if we work together, we shall get back a good deal of the lighting which has gone to electricity in its first rush and blush.

There is another matter I should like to refer to. Mr. Jackson spoke of the value of service and advertising. I am now speaking of the power of the Press. I have here the "Western Mail" for yesterday, and through the friendliness of the Press we have a very large column devoted to the Presidential Address at this meeting; and not only that, but also a leading article on the Gas Industry and its trials. In dealing with service to the consumer there are several parties interested, and I would like to quote one small paragraph from this leading article dealing with the Industry. It is as follows: "Stirred to new efforts by competition, the gas companies and their collaborators in the manufacture of equipment for lighting and power have not only preserved the Industry of gas production but have greatly extended its range of usefulness." In the case of my own Company, a year ago we had a fitters' concert, and I took the occasion to appeal to them to put sport into their work and do their very best as salesmen for the Company. This, I am glad to say, has borne fruit very much in excess of what we anticipated. It should be remembered that the fitters in an undertaking have the entrée into the houses of the consumers, and the housewives listen to them; and I can assure you that by getting the co-operation of the fitters as salesmen and service men, business can be greatly increased. As Mr. Jackson has pointed out, we have had very great depression in South Wales. In addition, a large number of people were called upon in January last to pay income-tax where they had never paid income-tax before, while those who did pay income-tax were called upon to pay a great deal more. Therefore it was felt that the sales of appliances might drop off. However, I am glad to say that with the co-operation of the fitters the sales did not drop off from those of a bumper year; indeed, the sales of apparatus from January to March this year have increased by 50 per cent. That has an important bearing in relation to getting the help of the fitters in co-operation to push the sales of apparatus as they have special opportunities of doing. There is one other plea I would make in regard to the quotation from the article I have just read to you, and that concerns co-operation and collaboration with the manufacturers of appliances. In fighting our competitors, electricity and oil, we often call in the makers. In the Institution we have broadened the

basis; representatives of the manufacturing firms have been admitted as members. In the Wales and Monmouthshire Association only at the last meeting we admitted a large number of representatives of manufacturing firms; and I am sure that is all to the good. They are not voting members, but they have been made associates, so that they can keep in touch with us and follow our deliberations and join with us in the fight. I am afraid there are one or two isolated cases where even to-day the manufacturers' representatives are not looked upon as favourably as they might be; but in the battle before us I think we want every force we can get to assist us in promoting the good of the Gas Industry.

Lady Inspectors.

Mr. R. Bruce Anderson: I should like to say how I welcome this paper, because the author was for some time one of my assistants. He served part of his early days at the Waterford Works, which have been a sort of gas university for men who have gone out to manage large works in other parts afterwards. Mr. Jackson, by the results he has obtained at Neath, has shown that he has taken advantage of his experience at Waterford and other places. He started at Neath in 1915—17 years ago—so that I am going back some years. The paper draws attention to the fact of the author having been successful at Neath with lady inspectors. I tried the experiment of a lady officer at Waterford. She happened to have been an actress, and we thought she would know a little about human nature and would be able to address the lady householder in a way, perhaps, that a man might not be able to do. We sent her round from works to works—we had a number of works in Ireland with which we were connected—and she spent two or three months in each town. The reports on her were very much in favour of her work, but they were very much against the idea of putting a lady to do this work at all. All those works were situated in Ireland, and many Irishwomen resented the intrusion of a woman into their domestic affairs. They did not mind a man officer coming round, because he did not understand what ought to be done; but they were a little chary of a woman coming into their homes where they might be failing in doing the right thing. The result was that we continued this for about a year and then dispensed with the services of that woman officer. I have always had a feeling that a woman ought to do this class of work, in the same way that some people claim that women should be architects of domestic dwellings; but anyway the experiment was not entirely successful in the case I have mentioned. We took up the question of a lady demonstrator at Waterford, and she was getting on very well when, unfortunately, her health gave way, and so far we have not replaced her. At the moment the wife of one of our managers is going round and is holding some very successful demonstrations. I attach considerable importance to the fact that a demonstrator attached to the undertaking is out to sell gas, whereas if you link up with the manufacturers of cooking stoves, &c., through their demonstrators, they are out more to sell their cooking stoves than to sell the company's gas. Therefore we have our own equipment for exhibition purposes, and we send this lady round from town to town. She carries all her stage gear with her; and I must say that we are very satisfied with the results she is producing.

Attention is drawn in the paper to the training of these lady inspectors and undoubtedly they have to be very well trained. They ought to understand the various parts of the apparatus they are going to advise upon, and this cannot be picked up casually. It must be done by training in the works beforehand.

Cost of Stores Systems.

Mr. Jackson also comments on the saving he has effected in introducing a stores system, a matter of £300 in the first year, which indicates that the system must have justified itself; but in connection with these stores systems I am very doubtful whether their cost is always justified. It depends on the magnitude of the concern. The objection I have to them is that you are apt to lose sight of the timber on account of the trees. If you get your mind in such a state that you have to consider where every type of accessory has gone to, you become more of a bookkeeper than an experienced accountant, who focuses attention on the more serious matters. In our case we take half-a-dozen articles—say cookers, mantles, taps, &c.—and keep a regular stock account of them at intervals; and if we find they are all properly accounted for, we assume there is no leakage taking place in other directions. A sporadic audit of that sort is better than the elaborate systems sometimes established and which can break down. I had a case a little while ago where I had to report upon a gas undertaking. I had been looking through the accounts for five or six years, and I noticed that the sundry stores were growing enormously, and thought there must be something wrong. I therefore asked for the stock book. I was in the manager's office at the time; and he said would I mind going down to the store room. I pointed out that it was raining, and said that surely we could have the stock book brought into the office. The reply was that it would take two men to bring the book along. So I went down to the store room; and sure enough the stock book was a great stack of cards held in timber frames with rope handles, and when we came to check the stock books with the stock actually in the stores there was an enormous deficit. There was no relation between the stocks on the works and the stock book. That is what I am afraid is likely to happen when you have these elaborate store rooms. It has been successful at Neath, but I urge Mr. Jackson to be very careful. In connection with this, we have a very simple form of stock book. It is arranged in parallel for seven years; the stock is written in once and there is plenty of space for additions from year to year in the other columns. This saves writing up the stock every year and it avoids anything that was in stock in the previous year being overlooked in the next year, as very often happens when you stock exceptional items.

Drying of Gas.

Regarding the gas drying plant, Mr. Jackson mentions that he has had very successful results, but I am wondering whether he has experienced any trouble from gumming, as some of us are experiencing. This is giving us a considerable amount of trouble, and we shall have to find some remedy; but what I am afraid of is that it is a slowly growing trouble which may, perhaps, be very serious in the future, in connection, for instance, with the gumming of governors and taps, &c., in various apparatus. When using gas for industrial purposes the trouble may grow and the efficiency of the plant may gradually be diminished. It is a thing which will require very serious attention, or we shall have great trouble in the future. The complaints at Neath, we are told, have been reduced from 998 to 211 in the second year, and then to 117. Why did the number fall so much in the second year. I should also like to know whether the bulk of the complaints were due to naphthalene or to moisture in the gas causing rusting, &c.

Another very good thing that Mr. Jackson has introduced at Neath is selling apparatus through slot meters instead of actually paying over the rebates. We have done that for some time and consider it very successful, because the slot consumers are now able to obtain irons, fires, &c., which are of great use to them and which they would never have had the money to buy in the ordinary way. It is a risky business for gas companies to lend out a heterogeneous mass of gas apparatus. The public is now accustomed to the "Drage way," and it is very difficult to get them to pay for anything straight away. If you give them easy terms of payment you can sell the goods. There is one thing in Mr. Jackson's tables that I do not quite understand, and perhaps he will explain it. He gives his hire-purchase sales as something over £5000 per annum, but in one of the tables he shows the balance due thereon as only £1700. I cannot quite reconcile the figures; are the purchases an aggregate of years, or is the £5000 a very fine turnover?

The Leakage Bogey.

I notice that Mr. Jackson draws attention to the fact that he has reduced leakage from 21 per cent. to 9 per cent. That is a matter on which I congratulate Mr. Jackson, but leakage is a great bugbear and bogey to which I think we are apt to pay far too much attention. Mr. Jackson is speaking of a small undertaking, and I am associated with a number of small undertakings; and I find this question of leakage one which gives more trouble between the directors and manager than any other. One piece of advice given by a qualified accountant who is a friend of mine, is that the best cure for leakage is to lower the water line of your meter! That is rather a mistaken dictum, but there is a good deal of wisdom in it, because by doing so the manager escapes a tremendous amount of worry from the directors. One of the things so dear to the heart of a director is to take the make of gas and the sale of gas, and say that the difference is leakage. After all, the loss is represented only by the manufacturing cost; and even if you were to reduce the leakage to anything that might be possible you would only get a very little more profit. In Uddingston I believe gas was blown away because of the profit made on residuals. One point I very strongly congratulate Mr. Jackson on is the increase in consumption per consumer, from 19,000 c.ft. per consumer to 26,000 c.ft. per consumer during the time he has been there.

Matters of Policy.

Dr. E. W. Smith: I wish to congratulate Mr. Jackson on his paper, which he claims, and we affirm as being correct, to be a paper advocating a progressive, aggressive policy. The more the smaller undertakings adopt an aggressive

policy, properly directed, with intelligence, such as Mr. Jackson has done, the better for the industry. It is a very good thing to have the lead of the Gas Light and Coke Company, the South Metropolitan Gas Company, and Birmingham. Those undertakings are spending their time largely in neutralizing the effect of a number of small undertakings which are not adopting a constructive, useful, and well-directed aggressive policy; and it seems a pity that that should be so. Mr. Jackson's paper indicates that the policy he has adopted, which he would not claim to be applicable to every undertaking in detail, is applicable in general. I believe in this demand for an increased technique and more research, which is all justifiable, but the more important thing to the Industry is policy; and all matters that affect policy will have more to do with the development of the Industry in the immediate future than discoveries of improved efficiencies, and so on. As some of us were discussing last night, I believe that the direction which our President has given us this year, in confining most of the papers to broad questions of policy rather than asking us to discuss technique at this annual meeting, is a very wise one. One of the best things he has done has been to decide first that we want a paper on the working of small undertakings with a progressive policy, and, secondly, to have asked Mr. Jackson in particular to deal with the subject.

Mr. Jackson has written a paper which is not subject to much criticism or discussion; it is a statement of fact, but it is interesting. The point, however, in which I am particularly interested has been given only 14 lines—namely, the importance or otherwise of his carbonizing plant. But in those 14 lines he tells us what it costs, and so on. I think it is indicative that he is of the opinion that, properly run—and, after all, I think that is the real lesson of his 14 lines—there are carbonizing plants to-day, in fact, all carbonizing plants of well-known types to-day, which are capable of giving such satisfaction that the engineer, if he understands his plant and runs it properly, does not need to bother about that side; and therefore he can get on with a progressive policy and other matters.

Gas Drying Justified.

The question of whether gas drying and naphthalene extraction should be adopted in all works is a very important matter. It is significant that there are some large undertakings to-day that have adopted the policy of believing that it is not necessary, and they are exerting quite a big influence in the Industry. There is nothing aggressive, nothing propagandish, about that, but the mere fact that they do not dry the gas is sufficient to cause many undertakings to say that it is unnecessary for them also. I can speak quite independently on this, but I believe all undertakings will find an advantage in gas drying, wherever they are, ultimately, and that the indirect advantages are such as to justify the system of gas drying. I was always under the impression that at least 50 per cent. of gas undertakings using continuous vertical retorts only never required to wash for naphthalene. That conclusion was based on the fact that naphthalene troubles were non-existent in a large number of cases. It is well known that there are many vertical retort installations that give very large quantities of naphthalene on the district, and I am wondering whether Mr. Jackson can tell us what his naphthalene tests actually are on the district, the naphthalene in the gas, and whether his troubles have been due to naphthalene because this question of gummy deposits is important, and it is quite possible that the gummy deposits are largely accentuated through naphthalene extraction. In other words, through the washing of the gas with oil and bringing the gas into contact with oil, possibly there is being taken out of the gas some of those heavier hydrocarbons that might eliminate the gummy deposits. It is just a suggestion, and I do not know whether, with gas drying and naphthalene extraction, gummy deposits have been experienced.

Spending Money to Save Money.

The great lesson that Mr. Jackson has brought out in the whole of his paper is that it pays to spend money in order to save money; and if that lesson can be brought home there is no doubt that there will be an aggressive and progressive policy all round. But it is not just the spending of money; it is the spending of money wisely, after having surveyed all the possibilities in your undertaking, indicating where money can be spent with advantage. Take the question of coke. Mr. Jackson, I think, has completely ignored the whole subject of coke, and I would ask him just to tell us why, because it would please me if I could realize that he either had or intended to have included in his progressive policy something relating to a considerable improvement in the production of coke, the grading of coke, and particularly in the selling of coke. I am still a believer—and I know that there are a good many who agree—in the view that the coke is the important subject still in the Gas Industry to-day. Lastly, can Mr. Jackson tell us a little bit more about the use of the high-quality gas, of 1500 B.Th.U., whether it is necessary to dilute it, or whether he has special methods of injection of air, what the efficiencies are, and so on?

Parallel Work at Shrewsbury.

Mr. C. M. D. Belton (Shrewsbury): I should like to add my congratulations to Mr. Jackson on the presentation of this paper to the Institution, because, after all, although the larger undertakings can teach us a great many lessons, the smaller undertakings are greater in number, and it is the efficiency of the smaller undertakings, I think, that gives us our reputation throughout the country. If we can maintain or increase the efficiency of our service to the public in a large number of smaller undertakings, then we shall not only improve the reputation of the Industry but we shall help those larger undertakings which are fighting other battles for us. I am particularly interested in the paper because it records experience which is very parallel to my own. For the last 12 or 14 years I have been going through a process of modernizing and bringing up-to-date every portion of my undertaking, and certain features correspond very closely to those that Mr. Jackson has recorded. One feature I should like to refer to, in respect of which he has deviated from my practice, is in the employment of lady inspectors. During the war time I had experience of employing several, and I was rather glad, at the end of the war period, to be able to get rid of them. I notice that the amount of work that is done by these lady inspectors in Neath is rather remarkable. The paper states that they visit 27 houses per day. I cannot understand how maintenance work can be carried on quite in that way, because this gives an average of about 18 minutes per house, not allowing for any walking time to and from the works, or between the houses, or anything of that sort; and it either indicates that a very superficial survey takes place during that period, or that there is no apparatus in the houses worth attention! Another point about the employment of these lady inspectors is that they are only partially trained, and I notice that one of their duties is to report special complaints to other inspectors in other departments, which means further annoyance to the consumers, and must result in something like the multiplication of the plumber and the boy business, because there must be several series of visitors to the houses. In my own case it might be interesting to let you know that we employ five maintenance men, and they call on all types of consumer except the large works. Their work is analyzed into ten groups of appliances, each appliance counting as a point or a unit—*i.e.*, cookers, fires, boiling rings, fittings, burners, accessories, and so on. Every single item is counted as a unit, and we find the average time spent per unit is about 69 minutes. That is the average for the last 42 weeks, during which time these men have attended to 8784 points. This, of course, includes a considerable number of large appliances which need to be brought in from the consumers' premises, such as large boilers in cafés and places like that, which are attended to. Apparatus requiring new material has to be charged for at the special rates, as Mr. Jackson does. The cost of service is an interesting figure. In Mr. Jackson's case it works out at 0·41d. per 1000 c.ft., after giving credit for profit on sales. I find that my corresponding figure is 0·6d., which is fairly good confirmation, perhaps.

With regard to the training of outdoor and selling staff, this is a most important point and one which I have found to be of the utmost necessity. We need to be able to have an efficient staff from the beginning, and even the selling staff requires to have some training in fitting work. The best salesmen must have a practical knowledge as a foundation for their work, and after selecting the best type of boys to go through the fittings department as fitters, we found that we were not developing the sort that really made salesmen; and so we are getting rather better educated boys and putting them through some training, and developing them into salesmen. It is said that salesmen are born and not made, but unfortunately, there are not enough born salesmen to go round, and so we have to make them.

There is only one other point I should like to mention, which is again in parallel with my own experience. During the last ten years Mr. Jackson records an increase in consumption per consumer, and parallel figures relating to my undertaking are as follows: In 1921 the average consumption per consumer was 27,400 c.ft., while in 1931 it had risen to 30,900 c.ft. That includes both slot meter and ordinary consumers. The figure for slot consumers is 21,800 c.ft., and that for ordinary consumers is 47,300 c.ft.

Mr. Jackson has had a unique opportunity of taking office in an undertaking which needed a man of his calibre, and I congratulate him on the work he has done.

Gas Consumption in South Wales.

Mr. W. H. Johns (Swansea): I should like to take this opportunity of congratulating Mr. Jackson on the very

excellent paper which he has given to us this morning. Taking my cue from the President I will not say any more on that point at this moment, but just this—that Mr. Jackson must be very proud to see so many present at the tail-end of the meeting this morning; and this to my mind indicates the paper is a most practical and interesting one to a large number of members of the Institution, and I am sure he will be well repaid by the excellent discussion.

Like Mr. Madden I have been in close contact with Mr. Jackson in connection with the development of his undertaking, because our works are situated only 8 miles away and we also have been constructing new works to cope with what we hoped would be a substantial increase in the demand for gas in South Wales. Unfortunately, owing to the depression that has been with us for some considerable time and does not appear to be lifting at the moment, the output of gas for that reason has been arrested; and I am with Mr. Jackson in believing that the depression is also responsible to a certain extent for the low average consumption that Mr. Jackson and other managers in South Wales have been suffering from for some time as compared with the figures given by Mr. Belton. We have, of course, to remember that conditions vary very considerably. In South Wales, where coal is given free of charge—most of the people are interested either in colliery workings or shipping, and even in connection with shipping coal is given free to a good many workers—the average consumption, of necessity, must be much lower than in residential centres like Shrewsbury or Bath, where the consumption is extremely high, and, of course, a very satisfactory one. The majority of consumers, however, in districts such as South Wales are content to use a gas ring only, and of necessity consumption per consumer in such circumstances must be low.

I would like to ask one or two questions, and at the same time, with Mr. Jackson's permission, I am going to add a little to what he said on the question of the application of high calorific value gas to industrial purposes. First of all I should like to ask Mr. Jackson what price he charges for his gas for public lighting purposes as compared with the charges made by the Electricity Undertaking. I believe both undertakings are municipally owned in Neath, whereas we in Swansea are fighting against an electricity undertaking pushed without any question of gain by the Corporation, very much to our disadvantage, and we have not been able to hold that load, although we have re-organized the public lighting and given a good light satisfactory to the majority of people in the town and to motorists in particular. Nevertheless we are losing the public lighting business because the Corporation will not allow us to give a competitive price. It would, therefore, be interesting to know the price at which Mr. Jackson obtains that load in Neath. It is very satisfactory to know he has been able to retain it, and the same remarks apply in connection with the retention of the use of gas in council houses in Neath, where, of course, the competition is the same as it is with regard to public lighting. Although we lost the public lighting load the Corporation do not assume the attitude taken in some districts with regard to electricity in council houses; and I am glad to say we have not suffered to anything like the extent that gas companies have suffered in certain parts of the country, where we have heard recently that cement has been put into the gas pipes to prevent people in the council houses using gas. The Corporation of Swansea allow us to fix gas cookers, gas fires, and gas boilers; and it would be interesting to know what class of competition Mr. Jackson is having from what might be termed his brother in charge of the electricity undertaking at Neath.

One other thing is in connection with the system Mr. Jackson has adopted of selling extra fittings to the slot consumers by means of the rebate on slot gas. Has he found any disadvantage in such methods? We have recently given slot consumers simple-hire cookers and fires and simple-hire wash-boilers, with the idea of obtaining the rental for such apparatus from the rebate on the slot meter consumption. Many times, however, there has not been sufficient rebate to enable us to get the whole of that rental. There may be sufficient only to get the rental for the fire; and inasmuch as our slot meter collectors draw a small commission for obtaining the rental from slot consumers for the gas cookers, and they do not get a commission in respect of the rental for the gas fire and wash-boiler, we find they credit the returns from the rebates towards the cooker costs. Unfortunately we find that the collection for the rental in connection with the fires and wash-boilers is getting rather behind-hand. I should like to ask Mr. Jackson whether he hires fires on such terms to his slot meter consumers, and also whether he gives a free cooker to slot consumers. We do not; we charge a small rental.

An interesting point has been mentioned by Dr. Smith in connection with naphthalene. I designed my new works, and being rather old-fashioned I put in horizontal retorts. I was told that among other things I should suffer from naphthalene troubles. I also put in a naphthalene extraction plant, but not a dehydrating plant; and I am pleased to be able to tell you that, notwithstanding the fact that owing to the construction and design of the connections from our water gas plant we were unable to arrange it in such a manner that the whole of the make of gas could go through the naphthalene removal plant, but only coal gas, which has contained as large a percentage as 60 per cent. of carburetted water gas, the naphthalene coming out of the holder is extremely small with horizontal retort working, because we have installed an extraction plant to take out the naphthalene. I am very much surprised to find, after what I have heard and read in the Press, that there are those who have erected vertical retorts who are suffering from naphthalene complaints. I always thought that in putting in these vertical retorts the necessity for naphthalene removal would not exist. However, one lives and learns. Before we built our new works we were inundated with naphthalene complaints because we were working on inclined retorts; and those of you who have had experience of these know that at times, with the variation in coal supplies, the greatest difficulty was experienced. I say "was" because it is practically extinct to-day. Nevertheless, we in the early days had a large percentage of naphthalene, and it took about 2 years to wipe out the accumulated deposits in the town mains. To-day, however, I am very pleased to say that we are working with four or five less gangs of service layers, who were really naphthalene removers in the past when the old works were in operation.

Subsequently Mr. Johns writes: I was offered oil gas by the local refineries some short time ago, and I went into the possibilities very carefully with the assistance of Mr. Cheetham, of Messrs. Humphreys & Glasgow, Ltd., who has had considerable experience, in the United States, of the application of oil gas in conjunction with town gas supply. I understand Mr. Jackson is in the very fortunate position of being able to deliver oil gas direct from the source of supply to industrial consumers, by means of a special main, and converting it to the required quality at the point of supply. These happy conditions do not apply to Swansea, and I was obliged to consider delivery of oil gas to the Morriston Gas-Works, some four or five miles from the Refineries. The oil gas could be utilized in two ways:

First for the production in a "reforming" plant of a finished gas which may be substituted for the present base load mixture of coal gas and carburetted water gas; and

Secondly, for the "cold enrichment" of blue water gas.

I had to consider, in respect of the first proposal, the question of the relationship between the productive capacity of our works with both present and estimated future demand. As a matter of fact, we are well placed in regard to reserve plant—our works is of fairly recent construction—and as the scheme involved fairly heavy capital expenditure on plant which would be submitted for existing, and efficient, units, the estimates indicated that the scheme would not be remunerative. It is apparent, however, that had we been considering an extension of manufacturing plant our considerations would have been somewhat different.

In regard to the second proposal—the "cold enrichment" of blue water gas; the substitution of oil gas for gas oil—much depends upon the price of the oil.

Three methods of delivery of oil gas were considered: First by pipelines, initial pressure 100 lbs.; secondly, in high-pressure rail cars, at 150 lbs.; and, thirdly, in a liquefied form in rail cars. The pipeline was ruled out on account of capital cost, and delivery in high-pressure rail cars on account of the heavy cost of carriage. My considerations were therefore concentrated on delivery of a liquefied gas in rail cars.

Certain modifications to our plant would be needed, and a high-pressure storage tank and a gas mixing apparatus would have to be installed. The question of H_2S would have to be carefully watched, and perhaps primary purifiers installed unless the H_2S content of the oil gas could be maintained at less than 600 grains per 100 c.ft. At any rate, the question resolved itself into a comparison between the commercial values of gas oil and oil gas, and on the basis of the price quoted for the oil gas the gas oil came out cheaper. I am, however, still in negotiation with the Refineries on this question of price.

Mr. J. E. Kenshole (Merthyr Tydfil): I should like to congratulate Mr. Jackson on his paper and upon the reconstruction work he has carried out at Neath. Most of the points have been dealt with by previous speakers, and I shall detain you but a very short time. In Table I. he gives the price of gas in 1919 as 5s. per 1000 c.ft., which is equivalent to 14·11d. per therm for a 425 B.Th.U. gas. I should like Mr. Jackson to tell us what quality of gas he was supplying at that time, and whether it was supplied on an illuminating or a calorific value basis, because the Gas Regulation Act was not passed until 1920, and, generally speaking, I think gas was supplied up to that time on an

illuminating basis. With regard to service, which has been referred to by previous speakers, Mr. Jackson is unique in that he employs lady inspectors, and the service appears to be very good, the cost to the department being low. He tells us how the lady inspectors are trained, and then he says they get three months' specialized training with the Chief Maintenance Inspector. Perhaps he will tell us whether the Chief Maintenance Inspector is a qualified gas fitter or a lady inspector who has had advanced instruction.

The results of his reorganization have increased the gas consumption per consumer from 18,400 c.ft. in 1919 to 25,500 c.ft. in 1932. That is very satisfactory, and justifies the policy adopted. With regard to references to Chart 1, it will be observed that there was a drop in the consumption per consumer of 2000 c.ft.—*i.e.*, from 20,800 to 18,800—in 1921. Presumably this was due to Mr. Jackson having increased the price of gas in 1920, and, of course, also to the South Wales coal strike of 1921. From 1921 to 1924 there was a very marked increase in the consumption per consumer, and it would be interesting to know whether Mr. Jackson had put on any large consumers for commercial or industrial purposes at that time. In 1926, the year of the national strike, the consumption per consumer increased slightly (by 300 c.ft.) over the previous year, and perhaps Mr. Jackson will tell us whether this was due to more apparatus having been installed by the consumers, thus creating a larger domestic demand, or was it due to a larger demand for gas for industrial purposes? The inclusion of the Briton Ferry Council area in the Neath Borough and the amalgamation of that gas undertaking appears to have been of distinct benefit to the gas undertaking as at present constituted. Perhaps Mr. Jackson would tell us what benefits the Briton Ferry consumers received by the amalgamation, and the price they paid for gas before and after the amalgamation.

With regard to his dri-gas plant, I, like Mr. Johns, was under the impression that with vertical retorts naphthalene troubles did not exist, but I was rather wondering what had been occurring. Possibly the naphthalene trouble was due, at Neath, to the manufacture of water gas. If so, perhaps Mr. Jackson will be able to tell us what percentage of carburetted water gas he was making at that time, and the naphthalene content of the gas which was being distributed. Like Mr. Johns, of Swansea, we have horizontal retorts. We wash our coal gas, but not the carburetted water gas, with oil in a Livesey washer, and I may say that our costs for attending to consumers' complaints over the last year were very much the same as those at Neath, our works being approximately the same size, Neath having a slightly larger output. I notice that for the year ended March, 1932, the cost of attending to district mains—I take it that is syphons—was only £1 14s. I should like to know whether Mr. Jackson does not, as a matter of precaution, send a man round at regular intervals, and, if so, how often he sends him. He states that one of the benefits of the dri-gas installation is that district pumping of syphons is entirely done away with. We have no dri-gas plant at Merthyr; we wash with oil.

With regard to sales to slot meter consumers, and the sales of apparatus against monies collected, I should like to ask Mr. Jackson if he has considered extending the rebate system to fitting up the houses—*i.e.*, fitting up workmen's dwellings. This saves capital, and the undertaking gets the benefit of the increased quantity of gas as soon as the installation is paid for. At Merthyr we are doing very considerable business in this way, and though our district at the present time is a particularly distressed area, with 60 per cent. of the insurable workmen unemployed, we were able last year to increase our sales of gas, and for the present half-year we have again increased the sales of gas.

I congratulate Mr. Jackson again upon the work he has done at Neath, and especially the very great improvement he has brought about in the financial position of the undertaking.

The PRESIDENT: I regret very much that I shall have to close the discussion at this point, and I do so with the more regret since it has been of such a high order. I must apologize to several gentlemen who had desired to speak had there been time and whom time has not permitted me to call upon, but I will ask them kindly to send in written communications to the Secretary for publication in your "Transactions." I will now call on Mr. Jackson to reply to the discussion.

Mr. JACKSON: I know the time is short, and I will try to get through these various queries as speedily as possible. In the first place, it is a very great pleasure to me this morning to have three of my old chiefs sitting in this room—viz., Mr. Bruce Anderson, Mr. Kenshole, and Mr. Nuttall. I derived a very great deal of my early training from these three gentlemen, and I should like to acknowledge that here and now. Mr. Anderson is and has been a great analyst. He analyzes costs and that sort of thing, and down he comes! [Laughter.] I can tell you one thing that he played with very great effect these analyses of costs upon my young brain when I first went to Waterford at the age of 22.

With regard to lady inspectors I have found that for repetition work—this was impressed upon me during the war years—women are infinitely better than men, and maintenance is to a very large extent repetition work. I find that the ladies have easier access to the houses than men do. I have tried men and youths at this without much success, and then I had the lucky idea of trying a lady whom I was thinking of discharging shortly after the war years. I put her on to this job. I gave her training first, and she has worked up to the point where, as I have said, we now employ five of these lady inspectors, and I am entirely satisfied with the results. The service given is excellent. All the time I have had this idea of service to the consumers at the back of my mind, and if you try a lady inspector I think you will get this repetition work done better than men can do it. Young men are very fidgety and flighty fellows; they want something with more initiative. The fitter, the man who fixes fires and apparatus, feels that he is doing something; but the repetition work that is done by these lady inspectors is better done by women. They are more fitted for it temperamentally. A woman will sit and crochet for hours, but a man would go mad if he had to do it.

With regard to the store system, I agree it should not be overdone, but we had a very excellent guide to follow at Cardiff.

As to Dri-Gas we have not had any appreciable difficulty with gum formation. We had a little at one time. Prior to installing the Dri-Gas plant we had three paraffin carburettors in operation, one on each district supply, and when this gum formation started to develop I immediately put these paraffin sprays back into operation, and I have had no further trouble with gum formation on any part of the district. I have had a little on the works governors and the district governors at the works, but that is immediately removed when the paraffin spray comes into action.

The bulk of the complaints were of naphthalene, but a considerable proportion were of moisture. Neath is a very old district, and I found that the mains and services had been laid at very shallow depths, and it meant that with all this new road work and heavy traffic trouble was caused in the mains, allowing moisture to enter. It would have meant a very heavy expense to cure that in the ordinary way, but the problem has been solved entirely by Dri-Gas.

The outstanding balance on hire purchase sales was queried by Mr. Anderson, but that is quite simple. The hire purchase sales are on a three-year basis, and the outstanding balance is the outstanding amount of collectable money due to the Department in respect of hire purchase sales at the end of each financial year—*i.e.*, as the hire purchase sales have increased in extent each year so the outstanding balances are bound to increase. It is just the same old story of any company which does hire purchase work. In a case like this they would have to increase their capital to meet the increased business. In our case we finance the whole of the work from the revenue account, and that is included in the outstanding balance due to the bank as shown in another Table, so that we have to the credit of our balance at the bank credits due to us by consumers of nearly £2000, and that is how it is accounted for. As to sales per consumer, Mr. Johns has mentioned a point there to which I was going to call attention. In a place like South Wales there are very many people interested in the coal industry and coal is delivered to them at 5s. or less per ton, and it is a job to get as large a consuption per consumer as in a residential district.

With regard to Dr. Smith I was very pleased to hear his remarks this morning, and particularly the emphasis he laid on the point of policy. I believe myself that we have been standing too close to the wood and cannot see over it. It is necessary to stand back a little and take a long view. Policy must be laid down not for a few months ahead, but for a long period of years ahead, and in this again you must have service to the consumer at the back of your mind all the time. With regard to carbonizing I have not laid any stress on that because the plant is good, and continues in good condition. It is 11 years old now, but it has not yet been re-set, and the work goes along quite happily. As to naphthalene, that is not due to the verticals at all. The verticals we put in started in 1921 and ran quite comfortably until we took over Briton Ferry, and even then we went on comfortably for a number of years. Then the consumption went up and we had to make carburetted water gas, and naphthalene troubles commenced. For a short period we did not make carburetted water gas and the trouble ceased, but immediately we resumed carburetted water gas manufacture our naphthalene troubles re-commenced. If you analyze your naphthalene from the water gas, as we did, you will find you are getting anything up to 10 grains, and that is where your naphthalene trouble

comes from, whereas with verticals I do not think we ever had more than 4 grains. With regard to coke I did not mention that because I never have any coke to sell. My coke is made from washed coals, and I have used washed coals extensively and exclusively for several years. Also for several years I have purchased my coal on a penalty bonus basis of 5 per cent. moisture and 5 per cent. ash, there being a penalty above this and a slight bonus below, with the result that the coke produced contains very little ash. We were one of the first undertakings in the country to adopt dry quenching by an oil pressure system. No water is allowed to be put on the coke at all, and the coke is of a very ignitable character containing very little ash, and for which we get a good price. The yard price even in South Wales is 26s. 8d. per ton, and the average price is just over 22s.

With regard to the use of 1550 B.Th.U. gas, I do not know that I have anything more to add now. We are still in the experimental stage. We have adopted this gas for one purpose very successfully, and are going to adopt it for the heating of mill furnaces, something like billet furnaces as you understand them in the industrial centres. It is too early yet to say anything about it, though we are hopeful. We shall be selling it at something like 2·9d. per therm for this particular purpose and making a handsome profit for the undertaking, which I think is very necessary. I think myself that in cases where we are buying coke oven gas or oil gas a certain amount should be reserved out of profits to provide for future extensions; otherwise you may be landed with a large amount of demand and no gas, and no capital to provide new plant with.

As to the 27 houses per day called upon by the lady inspectors, this job has been going on since 1921. Of course, 27 houses were not done per day at first, but we have got down to a position now where we can give each consumer one visit in every eight weeks, and there is very little opportunity for anything to go wrong in that time. In effect, we are able to deal with the trouble before it is a trouble, and I would like to put that before you as a little moral—to pick up your troubles before they develop into troubles. Again, with reference to the lady inspectors, part of their training consists of domestic science training at the County School, and that is one advantage of the girls over men.

The price we obtain for public lighting—a question asked by Mr. Johns—is 5d. per therm, and at that price we have no difficulty in keeping and extending the business. Undoubtedly public lighting is of great advantage to the undertaking, and has a very considerable advertising value. It is well worth while selling gas at a low price to get all this advertising value. Moreover, it is a load which comes on mostly after your consumers have gone to bed, and it is a load which would not otherwise exist. Therefore, it is something you can afford to sell at a reasonably low price. We have had severe electrical competition, but we still manage to keep our end up and to increase business. We have no simple hire for slot consumers at all. My experience is that whenever you have a hire scheme for slot consumers, it is very difficult to get the money.

As to the price paid for the 1550 B.Th.U. gas, I cannot give this at present because, though we have arrived at an approximate figure, the contract is not finaly settled.

As to the quality of the gas supplied in 1919 I would not like to say what it was, but the quality now declared at Neath is 425 B.Th.U., and our average over a series of years has been 431 B.Th.U. The sharp increase in consumption during 1921-24 was after we put our aggressive sales policy into operation. We naturally got a considerable increase, and you could not expect to keep up the same rate in subsequent years. There was no increase due to any industrial load at that time. Another reason for the increased sales of gas is that we were able to keep our supplies going during 1926 notwithstanding the shortage of coal due to the coal strike. The position with regard to the Briton Ferry consumers I can explain in this way. Pre-war, Briton Ferry paid 3s. 6d. per 1000 c.ft., while to-day the price is 3s. 9d. In Neath pre-war the price was 3s. per 1000 c.ft. To-day it is 3s. 9d., so that the Briton Ferry consumer is paying 3d. more now than pre-war and the Neath consumer is paying 9d. more, and I think that is very fair. As to siphons, we send a man round once every two months, and there has been no appreciable cost involved at all. One of our lamplighters does it. As to sales against rebate, we do not make any.

METRO-COALITE WORKS, EAST GREENWICH*

On Thursday last the Institution of Gas Engineers visited the East Greenwich Works of the South Metropolitan Gas Company

The Metro-Coalite Works at East Greenwich is the third plant installed by Low Temperature Carbonisation, Ltd.

The plant was put to work in January, 1931, and has been in continuous operation since that time with the exception of three months in the summer of 1931, when it was closed down to enable some slight alterations to be made. A general view is shown, from which it will be seen that five batteries have been erected. With the whole of these at work the throughput of coal is approximately 320 tons per day. Hitherto not more than three batteries have been in use together owing to the fact that time is required in the building of a sales organization to deal with the new product. At the height of the winter season deliveries of "Metro-Coalite" reached 700 tons per week.

Coal Handling.

The coal is brought by sea to a neighbouring Thames-side wharf and taken by railway wagons to the Metro-Coalite Works. Here it is discharged by a wagon tippler and elevated by a bucket conveyor to the top of a reinforced concrete bunker. This bunker is divided into two compartments, each holding 200 tons, so that two types of coal may be stored and blended as required. Blending is effected by discharging the coals in the desired proportions on to a common belt which conveys the mixture to a crusher from which it falls into a Büttner dryer. When necessary, a blend of three coals may be prepared by withdrawing simultaneously from the two bunkers and the wagon tippler pit. The Büttner dryer, a view of which is given, consists of a cylinder approximately 7 ft. in diameter and 30 ft. long inclined at an angle of 3° to the horizontal and rotated at approximately 3 r.p.m. by a 25-h.p. motor. The interior of the cylinder is fitted with longitudinal "vanes" which serve to pick up and drop the coal as it finds its way from one end to the other. Drying is effected by the sensible heat contained in the waste gas leaving the retort batteries, the hot gas being drawn by a 30-h.p. fan through the dryer in the same direction as the coal. Coal dust which may be suspended in the gas is removed by a cyclone dust extractor and returned to the main coal stream. The coal is removed from the Büttner dryer by a screw conveyor and elevated to the five retort house hoppers, each of which holds 65 tons of coal—that is, sufficient for 24 hours' working of each battery. These hoppers are fitted with two bottom discharge doors which feed the coal into 12-cwt. travelling skips from which the retorts are filled. Provision has been made for by-passing the dryer and also for blending "Metro-Coalite" breeze with the coal to be carbonized. The whole of the coal handling plant is designed to deal in 14 hours with 320 tons of coal—*i.e.*, the daily consumption of the plant.

The Retorts.

There are 18 retorts on each side of the battery. Although the retorts are uniformly spaced they are operated in pairs. Each retort consists of a vertical iron casting 9 ft. long, containing 11 carbonizing tubes into which the coal is fed, and also a smaller "gas tube." Each carbonizing tube holds approximately ½ cwt. of coal and tapers from a diameter of 5¾ in. at the bottom to 4½ in. at the top to facilitate discharging. Actually the retort casting is now made in two parts, the division occurring horizontally half way down the retort. This development was introduced partly to cheapen the cost of the plant, as it was found that the manufacture of one-piece castings led to a high proportion of "wasters," and partly to overcome difficulties due to expansion in working. The joint between the two sections is made with a gauze gasket covered with Purimachos cement, while to remove any possibility of the charge sticking at the joint the diameter of the tubes at the top of the lower casting is made slightly greater than that of the tubes at the bottom of the upper casting. Each retort is closed at the bottom by a hinged door operated by a chain wheel

* This account is from a booklet presented by the South Metropolitan Gas Company to members of the Institution on the occasion of their visit on June 9.

outside the battery and provided with a hole coincident with the " gas tube." Below each pair of retorts is a common cooling chamber fitted with a water sealed discharge door and lagged to prevent the temperature falling below that of condensation of tar vapours.

The function of the " gas tube " is to provide an outlet for the gases displaced from the cooling chamber when a new charge of hot " Metro-Coalite " is admitted thereto, and for any gas evolved from the hot charge while in the cooling chamber.

The gas is withdrawn through 6-in. cast-iron pipes. The trouble experienced during the early days of " Coalite " manufacture owing to pitching up of the pipes has been largely overcome by water jacketing. The trouble is still occasionally met, however, and to counter it a movable disc is provided inside each pipe. The disc is fitted with a central boss and is normally withdrawn from the path of the gas, in which position the boss closes a hole at the end of the 6-in. pipe. When any deposit forms in the pipe, a rod is screwed into this boss and the disc is pushed forward along the pipe until the obstruction is removed.

The connection between the retort and the hydraulic main is made by means of a water seal, which is kept full by condensate from the gas. The purpose of this is to overcome difficulties associated with the expansion of the retorts. The same pipe which terminates in the water seal at its upper end carries a Cort's anti-dip pipe at its lower end for sealing off the retort during charging and discharging.

through ports before entering the combustion chamber in which they mix. They burn with a long flame, the air being present in excess to ensure complete combustion. The flame does not come into contact with the retorts but imparts its heat to walls of refractory material which in turn radiate to the retorts. In this manner local overheating of the castings is avoided. Approximately 27 therms of gas is used for the carbonization of 1 ton of coal.

In order to facilitate the careful control of temperature necessary for the correct working of the plant, twelve portable pyrometers are fitted to each battery, all the leads being brought to a pyrometer house conveniently situated at the end of No. 3 Battery.

Carbonization.

Owing to the fact that the temperature inside the retorts never exceeds 600° C. the shrinkage of the charge during carbonization is small. In one respect this is an advantage since " Metro-Coalite " does not contain so many of those cracks which cause high temperature coke to break up during handling. Proof of this is furnished by the fact that the 2 in. shatter index of " Metro-Coalite " is higher than that of horizontal retort coke. On the other hand, owing to the absence of shrinkage, there is difficulty in discharging the retort if strongly swelling coals are used. The choice of coals is thus limited to medium swelling varieties or to suitable blends.

The operation of charging and discharging the retorts

GENERAL VIEW OF THE PLANT.

The hydraulic mains are flushed periodically with water to remove any deposit. This procedure has been successful during the working of the plant in keeping the mains clean. The gas is withdrawn from the hydraulic mains and passes through governors to the exhausters in the normal manner.

Method of Heating.

At present rich gas, from which the light oils have been removed by washing, is used for heating the retorts, but at a later stage it is proposed to substitute producer gas so that the whole of the gas made in the plant may be available for use as town gas. The gas is supplied under constant pressure through a ring main encircling the battery, the quantity admitted to each burner chamber being regulated by valves. Air for combustion is supplied under pressure through a rectangular main and, before being admitted to the burner chambers, passes through a series of 4-in. cast-iron recuperator tubes heated by the waste gas.

The retorts and combustion chambers are arranged alternately, making 19 combustion chambers and 18 retorts on each side of the battery. The recuperator tubes are placed on the centre line of the battery and the waste gases from each side meet after leaving the burner chambers and descend together round the recuperators to the waste gas flue which runs along the centre line of the battery near the bottom of the retorts. Butterfly dampers are provided in the short flues which connect the top of each burner chamber to the recuperator chamber.

Both the gas and the preheated air are distributed

takes place every four hours. The procedure is as follows. The pair of retorts to be charged is isolated from the hydraulic main by lowering the anti-dip seal. The door of the cooling chamber is then opened and the cooled charge of " Metro-Coalite " is dropped on to a tip tray conveyor which transports it to the primary screens. After closing the chamber door, the bottom doors of the retorts are opened by means of the chain wheels and the carbonized charges are allowed to fall into the empty chamber. The bottom doors are then closed and, after plugging the two " gas tubes " to prevent entry of coal, the other tubes are filled by the travelling coal skips. Any surplus coal lying upon the faces of the retort castings is removed, the plugs withdrawn from the " gas tubes," and the top doors closed. The retorts are connected to the hydraulic main again by raising the anti-dips.

" Metro-Coalite " Handling.

The " Metro-Coalite " discharged from the two rows of cooling chambers, one on each side of the battery, falls on to a central tip tray conveyor and passes over vibrating screens of $\frac{3}{4}$ in. mesh into a continuous bucket elevator which encircles the " Metro-Coalite " storage hoppers. On its way, the " Metro-Coalite " is sprayed with water to complete the cooling and to reduce dust trouble. The hoppers in which the finished product is stored are four in number and have a total capacity of 600 tons—that is, the output from three days' working. Each hopper is provided with four bottom discharges equipped with automatic weighing devices for filling 1-cwt. sacks or 28-lb. bags.

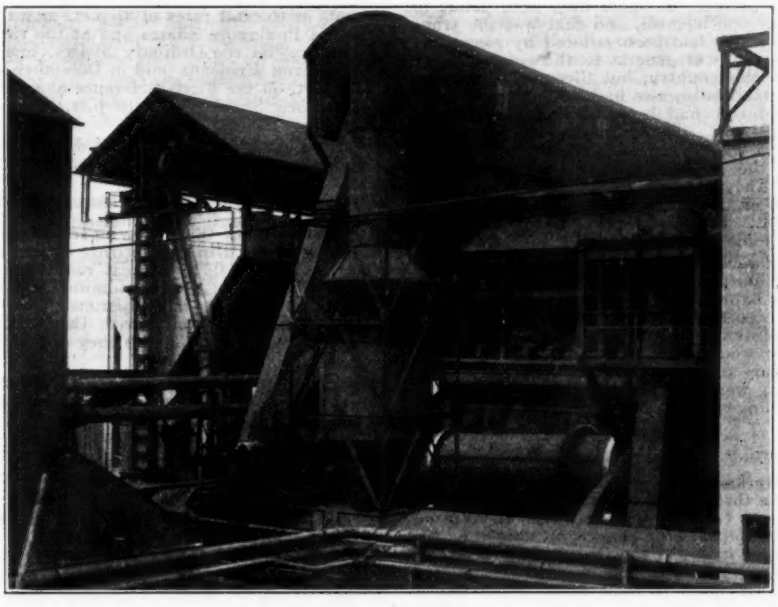
In order to remove any breeze formed in handling, the "Metro-Coalite" is caused to pass over secondary screens fitted to the bottom of each hopper before entering the bagging appliances. Up to the present time provision has only been made for loading "Metro-Coalite" into lorries, &c., at the loading platform.

Recovery of Bye-Products.

The entire plant for the treatment of the gas at the Metro-Coalite Works was supplied by Messrs. Simon Carves, of Manchester.

The rich gas from the retorts is led by the foul gas main to a Simon Carves-Ferranti electrostatic tar precipitator from which it passes to a sulphate of ammonia plant (not being worked at present) of the direct recovery type. The tar precipitator was originally installed to provide a clean gas for the sulphate plant, but as this is not being worked the precipitator is by-passed. The gas then passes through condensers to the exhausters and thence to two light oil scrubbers. These are towers 60 ft. high and 8 ft. diameter, filled with wooden slat packing over which gas oil flows. The light spirit is recovered from the enriched oil by distillation in the normal manner.

The whole of the plant is capable of handling twice the volume of gas that would be produced by the five batteries which have been erected and ample space is available for the installation of additional batteries and bye-product plant if the need arises.



THE BÜTTNER COAL DRIER, WITH CYCLONE DUST EXTRACTOR IN THE FOREGROUND.

Products of Carbonization.

The figures given below for the yields and characteristics of the products should be regarded merely as indicative of the results obtained. Low-temperature carbonization is still in a state of flux and modifications in the physical character of the coal carbonized and the period and temperature of carbonization are being made from time to time as further knowledge is gained. These changes in carbonizing practice naturally affect the quality of the products obtained and therefore the accompanying figures must be accepted with reservation.

"Metro-Coalite."—The main product of carbonization is, of course, "Metro-Coalite," this term being reserved for the product over 1 in. in size. The yield is approximately 12½ to 13 cwt. per ton of dry coal and the bulk density is 20 to 25 lbs. per c.ft. As sold it usually contains 10 to 12 p.ct. of volatile matter, about 3 p.ct. of moisture, and less than 6 p.ct. of ash. Grading tests are made regularly on spot samples to supply efficient control of the screens, and tests are also made to ensure the fuel produced being smokeless and of satisfactory appearance when burning.

The amount of breeze made is approximately 10-15 p.ct. of the total solid product, but it is hoped to reduce this figure.

Light Spirit.—At present the yield of unrefined light spirit obtained by stripping is between 2·7 and 2·8 gallons per ton of coal. Its specific gravity is 0·77 to 0·78 and the figure obtained by the retort test is approximately 60 p.ct. The spirit commences to distil between 30° and 40° C. and the dry point is in the neighbourhood of 200° C.

Tar.—The yield of tar on the dry basis is approximately 18 gallons per ton of dry coal; the tar acid content is approximately 35 p.ct., and the viscosity at 100° Fahr., as measured in a No. 1 Redwood viscometer, is 106 seconds. The specific gravity of the tar containing 3½ to 4 p.ct. of water is 1·02 to 1·03, and the calorific value is 16,000 B.Th.U. per lb.

Gas.—The yield of unstripped gas is 30 to 35 therms per ton of dry coal, the calorific value being 900 to 930 B.Th.U. per c.ft. and the specific gravity 0·62 to 0·65; the nitrogen content is approximately 8 p.ct. Stripping reduces the calorific value by approximately 100 B.Th.U. per c.ft. and the specific gravity by 0·07 to 0·08. Surplus gas not required for heating the retorts is taken by the East Greenwich Station of the Company and introduced into the foul main of one of the retort houses.

Suggested Moving of Blackpool Works.—The Blackpool Corporation General Purposes Committee have withheld approval of the decision of the Gas Committee to erect another holder at the present works, and asked the Gas Engineer and Manager to report fully on the cost and advisability or otherwise of moving the gas-works to another site on the outskirts of the town. All the members agree that the ideal thing would be to remove the whole of the works away from the centre of Blackpool if that were practicable. Two years ago, Mr. John H. Chew, the former Gas Engineer, prepared a report on the same subject, and estimated that the cost of removing the gas-works would be £390,000.

The Southern Association will Visit Ramsgate on Friday, July 1, when the works and offices of the Corporation Gas Department will be open to the members during the whole day, though it is hoped that inspection will be made in the morning. The members will be the guests of the Chairman and members of the Gas and Water Committee at luncheon at 1 o'clock at the Granville Hotel, East Cliff, after which it is felt that members and their ladies might wish to take the opportunity of visiting Canterbury Cathedral, and arrangements have therefore been made for anyone so desiring to be conveyed by motor coach to Canterbury, where tea will afterwards be served at the County Hotel.

Malta and Mediterranean Gas Company, Ltd.

GENERAL MEETING

The Annual General Meeting of the shareholders of the Malta and Mediterranean Gas Company, Ltd., was held on Tuesday, June 7, at the Offices of the Company, 59-60, Gracechurch Street, E.C. 3—Mr. A. M. PADDON, M.Inst.C.E. (Chairman of Directors), presiding.

The SECRETARY (Mr. G. Murray Burton) read the notice convening the meeting, together with the certificate of the Auditors; and by general consent of those present it was agreed to take the Directors' report and statement of accounts as read.

THE CHAIRMAN'S ADDRESS.

The CHAIRMAN, in moving the adoption of the report and accounts, said that the only matter in the report distinct from the actual figures to which he would refer was in regard to the retirement of Mr. C. J. Daun from the office of Secretary. In Mr. Daun the Company had lost an assiduous and faithful servant; and he was glad to be able to tell the shareholders that they had secured in his place a gentleman of great competence, whose future association with the Company would live up to the traditions of the past.

Turning to the affairs of the Company, the Chairman said that it hardly seemed possible a year ago that they could present accounts as satisfactorily as those they were about to consider. There was only one blemish, and that was the truncation of their business, which had been reduced by something over 7 p.ct. This, however, was generic to the Gas Industry at this time not only in this country, but throughout Europe, if not the world. Almost all businesses had suffered some limitations, and the Gas Industry had been affected both in this country and on the Continent. Therefore they could not deplore anything unusual in this reduction in their business. In every other particular the accounts would be found to be eminently satisfactory. They had lost in comparison with last year £2913 in the sales of gas, while receipts from residuals had been reduced by £785. This was all the tale of misfortune he had to tell the shareholders.

On the other side of the account they had saved on coal partly as a result of a reduced output of gas and partly as a result of economy the sum of £1750, while on maintenance and renewals they had saved £3679. When he told them that the amount expended on maintenance and renewals was just under 18d. per 1000 c.ft. they would realize that it was not false economy. The expenditure on works and apparatus last year had been heavy, and they were now reaping the benefit of this. There was therefore nothing adventitious in the development of this figure.

SATISFACTORY WORKS FIGURES.

The figures from the works were of an extremely satisfactory kind. They had in Malta three very able Officers in Mr. A. E. Buckley, the Engineer and General Manager, Mr. R. Wilson, and Mr. C. F. Wright, who was in charge of the accounts. Mr. Wright, he was pleased to say, was with them at the meeting that day. They were very fortunate in these gentlemen; it was the duty of the Directors to look after the technical matters, but the efficiency and economy in the working, which was in the hands of these Officers, found expression in the accounts before them, and these spoke for themselves.

They had made nearly 14,000 c.ft. of gas per ton of coal carbonized, which was a high figure, while unaccounted-for gas was only 8½ p.ct., notwithstanding the amount distributed and the scattered nature of their area interdelineated with very keen electrical competition—a result only produced by great persistence and skill on the part of the Offices in Malta. If they took away the 8½ p.ct. of unaccounted-for gas the sales would stand at something between 11,000 and 12,000 c.ft. per ton of coal carbonized. The other items in the account so nearly balanced each other that the figures were not useful for reference purposes. Their profit for the year was £1591 greater than twelve months ago in spite of the adverse circumstances to which he had referred.

PROFIT AND LOSS ACCOUNT.

In the profit and loss account the balance of net profit brought in from the last account, less the interim dividend, was increased by £1203, while the balance carried to the next account, subject to the final dividends for the year to March 31, 1932, was greater by £2510; so progress could be recorded in the financial direction. Their amortization account was increased by £2528, the reserve account by £1056, and general account by £4093. Their investments had increased by £7677, and were independent of the Company, and therefore were not subject to any variations in its fortunes. These investments, according to the valuation at March 31, 1932, amounted to £122,921, which was an increase in their market value, including that of purchases made during the year, of £14,257.

This statement, the Chairman thought they would agree, reflected a very satisfactory condition of affairs generally in a very unsatisfactory and difficult period. In regard to the future, their fortunes were local ones, which he had on many occasions described to them. Malta was a Government Station which was always subject to exotic and alien circumstances. Often just when they had settled down someone started trouble—either in Cyprus, Africa, or elsewhere—with the result that battleships, cruisers, and troops moved away, with consequent detriment to the Company's progress. They had weathered this sort of thing many times, however, and he did not think that their experiences during the next twelve months would be worse than they had been in the past. Establishments at Malta had been reduced to a low level, but considering the importance of the Station in their national politics it could not be reduced below a certain level, and he did not think they would experience any greater shrinkage. Their coal had been purchased in advance for the ensuing year, while there was a slight improvement in residuals; they found a little better market for their tar. So taking all things together he did not think their prospects were worse than they were a year ago.

The Chairman then moved the adoption of the report and accounts.

Mr. A. W. OKE seconded the resolution, which was carried unanimously.

DIVIDENDS.

The CHAIRMAN thereafter moved the declaration of final dividends at the full rates of 3½ p.ct. and 3¾ p.ct. on the First and Second Preference Shares and at the rate of 5 p.ct. (free of income-tax) on the Ordinary Shares, making for the year (with the interim dividends paid in December last) a total distribution of 7 p.ct. on the First Preference Shares; 7½ p.ct. on the Second Preference Shares; and 10 p.ct. (free of income-tax) on the Ordinary Shares.

Mr. FRANK H. JONES seconded this resolution, which was unanimously carried.

RE-ELECTION OF DIRECTOR AND AUDITORS.

The CHAIRMAN thereafter moved the re-election of Mr. A. W. Oke, being the Director retiring by rotation. Mr. Oke, he said, had been with them a great many years and was conversant with all matters of gas administration gathered from many points of view, and his experience was of great value to them. He had been associated with the Company in times of great difficulty, and he was sure they would wish to re-elect him in these times of prosperity.

Brig.-Gen. G. V. CLARKE, C.M.G., D.S.O., in seconding, endorsed what the Chairman had said; and the resolution was carried unanimously.

Mr. OKE briefly acknowledged, remarking that it gave him great pleasure to serve on the Board. They had passed through troublous times, and it was very satisfactory to find that they were now able to pay a dividend of 10 p.ct. free of income-tax.

Mr. F. W. CHURCH then moved the re-election of the Company's Auditors, Mr. Wiliam Cash, F.C.A., and Mr. Hyde C. Burton, at the usual remuneration of 40 guineas.

Mr. F. R. SMITH seconded, and the motion was carried.

Mr. HYDE C. BURTON acknowledged this renewal of their confidence on behalf of Mr. William Cash and himself.

VOTES OF THANKS.

The CHAIRMAN next moved a vote of thanks to the officers and staff generally of the Company. He had already commented, he said, on how much they owed to the industry of their officers. The results of the year's working were quite exceptional, and all they could do in their own interests was to give the officers and staff further encouragement not to grow weary but to grow bigger in their efforts.

Mr. F. R. SMITH, in seconding, remarked that he had some knowledge of Malta, and Mr. Buckley's name was a household word there. He very gladly seconded the vote.

This was carried unanimously, and in reply,

Mr. G. M. BURTON thanked them very much on behalf of the London staff, and he hoped they would always put before them every year accounts in a fitting manner, so that they could be easily understood.

Mr. C. F. WRIGHT also replied on behalf of the staff in Malta, and thanked the Chairman for the very kind things he had said about the staff. He would carry his words back to Malta and repeat them to the staff out there.

A vote of thanks to the Chairman and Directors was unanimously carried on the proposition of Mr. R. L. WILSON, seconded by Mr. A. D. DODGSON, which the CHAIRMAN briefly acknowledged.

Mr. DODGSON thereafter suggested that a letter be written to the retired Secretary, Mr. C. J. Daun, expressing the appreciation of the shareholders of his many years of loyal service to the Company.

The CHAIRMAN thanked Mr. Dodgson for this suggestion, and stated that such a letter should certainly be written to Mr. Daun.

This terminated the business of the meeting.

South Metropolitan Gas Company's Chemical Works

Impressions of Phoenix Wharf, East Greenwich,

By "A VISITOR"

The inspection by members of the Institution of these works on Thursday afternoon last was not less interesting than the visit to the Metro-Coalite Works.

The exhibition of ammonium products revealed that the Company is alive to all the markets which are available, and that it manufactures not merely an excellent ammonium sulphate for agricultural purposes, the crystal size of which is one of its striking features, but that it produces battery, super-battery, and industrial sulphates of almost British Pharmacopœia quality. When it is remembered that these various qualities of ammonium sulphate are prepared on a large scale (20 tons per day), one can form some idea of the advance in technique which has been made.

A sample of crude commercial ammonium bicarbonate exhibited was attractive in its physical qualities, and if the Rothamsted investigation which is now being conducted proves that ammonium bicarbonate is equally as satisfactory a fertilizer as ammonium sulphate, it would appear that ammonium bicarbonate will be manufactured by gas-works in this country in the future on a fairly large scale.

The ammonium sulphate plant and its auxiliaries—bagging shed and stores—are admirably disposed and well equipped. Apparently, there are four units of plant, each capable of producing 20 tons of ammonium sulphate per day. The disposition of the units is not identical, but there is uniformity in the various elements constituting the integral plant. Special steps are taken to conserve heat, and it was remarked that the consumption of steam does not exceed 30 lbs. per 100 lbs. of gas liquor distilled. The latter figure includes the steam required for the distillation of the devil liquor and automatic circulation and feed of the cream of lime.

The stills, several of which were erected thirty years ago, are of the Carpenter type, and are in excellent condition; there is a complete absence of external leaks. They comprise an outer shell, in which the distillation elements are placed. The latter have to be removed from the shell for cleaning.

The saturators are of special design; they admit of the automatic removal of tarry scum, and they combine features which admit of controlling the crystal size. Apparently, various sizes of crystals can be made, according to requirements. This represents something more or less unique in ammonium sulphate technique.

All the centrifugals are made of Monel metal, and we were told that several thousands of pounds have been saved by a study of this question, and the standardization and provision of all parts in this special natural alloy. The neutralization of the salt is conducted in the basket, with a weak ammonia solution, which is automatically obtained from the fixed still. The grain size of the salt bed greatly aids the percolation of the solution, and ensures uniformity of neutralization.

The dryer is made almost wholly of wood, and there is a marked absence of mechanical equipment. It is of the shower type, and distributes the moist neutralized salt over a series of triangular bars, the salt encountering hot air, at a temperature of 150° C., in its descent. The salt is circulated through the tower five or six times before the moisture content is reduced to the standard which has been adopted—viz., 0·04 p.ct.

The removal of the "Metro" sulphate from the drying tower to the stores is effected automatically by a combination of elevator and push-plate conveyor, having elm boards as the medium for transporting the salt, which can be distributed at any point in the stores. "Metro" sulphate is screened through a 10 by 10 mesh hexagonal screen before being bagged. The visitors had an opportunity of seeing some of the screens at work, as well as bags of "Metro" sulphate being conveyed to a barge in the river. The loading arrangements, either to barge or truck, are ideal, and we learned that 400 tons of "Metro" sulphate can easily be handled per day.

Various types and sizes of bags were exhibited, in which "Metro" sulphate was packed. This demonstration constituted a striking example of the pains taken by the Company to meet their clients' requirements in every particular. They obviously recognize that markets can only be maintained by quality of product and service.

The small plant manufacturing concentrated ammonia liquor was a feature of interest, and particularly the purpose to which the product is applied, reference to which will be made later.

The Company manufactures between 600 and 700 tons of 70 p.ct. sulphuric acid per week, in four units of plant, three of which combine four rectangular chambers to a set, and one—a new unit, erected in 1930—comprises four tower chambers of the exposed type, the leadwork of which is built within a light steel skeleton framework of vertical and circumferential angles and flats.

One battery of spent oxide burners and a rotary mechanical sulphur burner work together in conjunction with the new unit of tower chambers, which has a capacity double that of the other three units.

The sulphuric acid plant as a whole is well and substantially designed, and in an excellent state of preservation and repair. What attracted chief interest was the new acid plant, which represents a departure from stereotyped practice, and embraces new principles which have been developed by the Manager, Mr. P. Parrish. Hitherto, the old type of chamber did not assist in the removal of the heat of reaction. Many of the members of the wooden framework were in actual contact with lead. With the new type of chamber, air has unimpeded access to the leadwork and more efficient cooling is obtained.

But the outstanding feature of the new plant is the use of turbo dispersers, which disperse *cooled* acid to the four chambers at a temperature of about 20° C. Such cooled acid not only irrigates the walls of the chambers, but also descends as a mist in countercurrent flow to the reacting gases—sulphur dioxide, oxygen, and nitrogen oxides. The bombardment of the reactants by the minute vesicles of acid aids acid formation, by interaction with the SO_3 which is formed.

One of the disabilities with the old type of chamber was that no provision was made for the rapid removal of the SO_3 formed. Its existence as such created inhibition, and arrested acid formation.

In its descent, the dispersed acid is raised in temperature, and is withdrawn from the chambers at temperatures ranging from 45° C. to 30° C., according to the particular chamber from which it is drawn. The removal of the sensible heat of the acid being cooled for dispersion renders possible the reduction of the chamber space to an appreciable extent.

It has been found with this system, which has been called the *liquid phase system*, that it is possible to work at a space-time factor of 2 c.ft. of chamber space per lb. of sulphur per 24 hours.

By using dispersed acid, the surface temperature of the lead at the top of the chamber rarely exceeds 35° C., and at the bottom of the chamber 50° C. We were informed that these reductions of temperature have a marked influence on the lease of life of the lead, retarding crystallization and fracture.

It was interesting to observe that a two-stage water pump took the place of a dynamo, and pelton wheels were used instead of motors for driving the dispersers. The use of electricity is not encouraged.

An ammonia oxidation plant embracing three units was an object of interest, and was attractively laid out. Each unit had a rated capacity of 6 lbs. of ammonia per hour. The control had been centralized in the vaporizer house, where measurements of concentrated ammonia liquor in ccs., and air in cubic feet per minute, could be readily determined. The features of this plant were (*a*) the use of concentrated ammonia liquor, and (*b*) platinum-rhodium as the catalyst.

Hitherto it had been supposed that the presence of CO_2 and H_2S either inhibited conversion or caused difficulty subsequent to the converter. These adverse anticipations had not been experienced. Platinum-rhodium had been adopted as a catalyst because it was a more robust alloy, and had greater flexibility, than platinum. The oxides of nitrogen were conveyed by flanged earthenware pipes, suitably secured with wrought-iron bands and steel clips, to the four units of plant. This conduit system was quite interesting, if only from the point of view of its length, and the arrangement of admission to the various sets.

We were informed that a considerable proportion of the residue remaining after the combustion of the spent oxide is converted to a purifying material, which is sold under the name of "Metroxide." "Metroxide" is made of varying qualities, to suit the varying requirements of the gas-works, largely from the point of view of activity and porosity.

GAS MARKETS & MANUFACTURES

Stock Market Report.

[For Stock and Share List, see opposite page.]

The many international happenings which follow one another with such rapidity are mainly responsible for the uncertainty which has been experienced on the Stock Exchange for some time past. Last week was as difficult in this respect as its predecessor, and the volume of business was small and prices in most markets irregular. The long-awaited Lausanne Conference opens this week, and its deliberations will be followed with the keenest interest, for it is realized that at last a serious attempt is being made to solve some of the world financial problems and thus bring about a much-needed return of confidence.

Conditions in the Gas Market were much the same as the previous week, and prices continued to show a hardening tendency. Except in the case of the larger undertakings there was little stock available, and inquiries for the ordinary stocks of some of the smaller companies caused sharp appreciations in value. Among these, Hornsey consolidated improved 9 points to 97½, and Northampton 5 p.ct. 4 points to 84½. At these prices the respective yields on the basis of last year's dividends are £6 3s. 1d. and £5 18s. 4d. Attention was drawn last week to the unusually wide margin of Tottenham ordinary, and this has now been reduced to 5 points, resulting in an increase in value of 3½ points. Among other ordinary stocks to improve were Croydon sliding-scale by 2 points to 122½ and South Metropolitan by 1 point to 106½. Apart from *ex* div. markings, the only falls in value occurred in European by 5 points to 85 and (at the local Exchange) Newcastle units by 3d. to 19s.

There are still a few 4 p.ct. debenture and preference stocks in the List, parcels of which occasionally come on the market, giving a yield at current prices of round about 5 p.ct.—*e.g.*, Alliance and Dublin debenture at 77 (the present quotation of 72½ is obviously undervalued); Mid-Southern District preference and debenture quoted at 79½ and 80½ respectively; Newcastle preference at 80; Southampton debenture at 79½; and Tottenham debenture at 82½, business being done last week at 80.

Current Sales of Gas Products.

The London Market for Tar Products.

LONDON, *June* 13.

The values for tar products are unchanged, current prices being:

Pitch, 95s. per ton f.o.b.

Creosote varies from 3¾d. to 5d. per gallon f.o.b., according to specification.

Refined tar is 4d. to 4¼d. per gallon in bulk at makers' works.

Pure toluole is about 2s. 6d. per gallon; pure benzole, 1s. 8d. per gallon; 95/160 solvent naphtha, 1s. 4½d. to 1s. 5d. per gallon; and pyridine bases, 3s. 9d. to 4s. per gallon—all naked at makers' works.

Tar and Tar Products in the Provinces.

June 13.

The average prices of gas-works products during the week were: Gas-works tar, 34s. 6d. to 39s. 6d. Pitch—East Coast, 85s. f.o.b. West Coast—Manchester, Liverpool, Clyde, 85s. f.o.b.* Toluole, naked, North, 1s. 10d. to 1s. 10½d. Coal-tar crude naphtha, in bulk, North, 5d. to 5½d. Solvent naphtha, naked, North, 1s. 2½d. to 1s. 3d. Heavy naphtha, North, 11d. to 11½d. Creosote, *ex* works, in bulk, North, liquid and salty, 2½d. to 3d.; low gravity, 1½d.; Scotland, 2½d. to 3d. Heavy oils, in bulk, North, 5d. to 5½d. Carbolic acid, 60's, 1s. 8d. to 1s. 9d. Naphthalene, £9 to £10. Salts, 55s. to 75s., bags included. Anthracene, "A" quality, 2½d. per minimum 40 p.ct., purely nominal; "B" quality, unsaleable.

* All prices for pitch are now quoted on the basis of f.o.b. In order to arrive at the f.a.s. value at any port it will be necessary to deduct the loading costs and the tolls whatever they may be.

Tar Products in Scotland.

GLASGOW, *June* 11.

Pitch is in good demand for both prompt and forward delivery; but supplies are short in this district. Other products remain substantially as last reported.

Crude gas-works tar.—Actual value is now higher at 57s. 6d. to 62s. 6d. per ton *ex* works.

Pitch.—Inquiries are numerous, but distillers are disinclined to commit themselves at present. Export value is now higher at 85s. to 90s. per ton f.o.b Glasgow and, in the home market, 90s. to 95s. per ton is being obtained *ex* works in bulk.

Refined tar to Ministry of Transport Specification.—Quotations are steady at 4½d. to 4¾d. per gallon f.o.r. makers' works in buyers' barrels.

Creosote oil.—Supplies are not plentiful and value remains firm. B.E.S.A. Specification is 3½d. to 3⅝d. per gallon; low gravity, 3⅜d. to 4d. per gallon; and neutral oil, 3¾d. to 4d. per gallon—all f.o.r. in bulk.

Cresylic acid.—This market continues uninteresting with prices easy. Pale, 97/99 p.ct., is 1s. 1d. to 1s. 2d. per gallon; dark, 97/99 p.ct., 1s. to 1s. 1d. per gallon; and pale, 99/100 p.ct., 1s. 3d. to 1s. 4d. per gallon—all f.o.r. naked.

Crude naphtha.—Supplies are limited and value is 4½d. to 5d. per gallon, according to quality and district.

Solvent naphtha is quiet at 1s. 2½d. to 1s. 3½d. per gallon for 90/160 grade, and 11d. to 1s. per gallon for 90/190 grade.

Motor benzole is in slightly better call, but value is unchanged at 1s. 2d. to 1s. 3d. per gallon f.o.r. in buyers' rail tanks.

Pyridines.—90/160 grade is 3s. to 3s. 3d. per gallon, and 90/140 grade 3s. 3d. to 3s. 6d. per gallon.

Benzole Prices.

These are considered to be the market prices for benzole at the present time:

	s.	d.		s.	d.	
Crude benzole	0	7	to	0	7½	per gallon at works
Motor "	1	2	"	1	3	" " "
Pure "	1	6	"	1	7	" " "

New Capital Issues.

Colchester Gas Company.—Messrs. A. & W. Richards are instructed to offer for sale by tender £89,000 5 p.ct. perpetual debenture stock. Minimum price of issue, par. Tenders by 11 o'clock, Thursday, June 30.

Reading Gas Company.—We are informed by the Reading Gas Company that the issue of £60,000 of 5 p.ct. redeemable preference stock, to be redeemed in 1960, recently made by this Company, was over-subscribed nearly six times and realized very satisfactory prices.

South Suburban Gas Company.—The Directors of the South Suburban Gas Company are prepared to receive on or before June 24, 1932, sealed tenders for £200,000 of 5 p.ct. perpetual debenture stock, at a minimum price of issue of £105 per £100 of stock, to rank *pari passu* with the existing debenture stock of the Company. Stock may be tendered for in amounts of £10 or multiples thereof.

Trade Notes.

"Simplex" Water Gas Plant for Bordon.

The Bordon and District Gas Company have placed an order with the Vertical Gas Retort Syndicate, Ltd., of 17, Victoria Street, Westminster, S.W. 1, for an improved type "Simplex" water gas plant.

A "Nor-Rust" Contract.

A contract for sandblasting and "Nusting" the steelwork at Manor House Station on the Cockfosters extension of the Piccadilly Railway has been given to Messrs. Nor-Rust Liquid Lead Company, Ltd., of Iddesleigh House, Caxton Street, S.W. 1.

A Change of Address.

As from Monday, May 23 last, the offices of Messrs. Lighting Trades, Ltd., with which is associated the Welsbach Light Company, Ltd., were transferred from 30-31, Farringdon Street, E.C. 4, to 51-55, Garratt Lane, Wandsworth, S.W. 18; Telephone: Battersea 6008 (4 lines). The Company's City Trade Counter will remain at 17-19, Farringdon Road, E.C. 1, and their Showrooms at 30-31, Farringdon Street, E.C. 4.

Contracts Advertised To-Day.

Coal.

The Ellesmere Port and Whitby Urban District Council invite tenders for the supply of coal. [Advert. on p. 784.]

Exhausting Plant.

The Edinburgh Corporation invite tenders for the supply and erection of exhausting plant. [Advert. on p. 784.]

STOCK AND SHARE LIST.

Official Quotations on the London and Provincial Stock Exchanges.

[For Stock Market Report, see earlier pages.]

Issue	Share.	When ex-Dividend.	Dividends. Prev. Hf. Yr.	Dividends. Last Hf. Yr.	NAME.	Quotations. June 10.	Rise or Fall on Week.	Transactions. Lowest and Highest Prices During the Week.
£			% p.a.	% p.a.				
1,551,868	Stk.	Apl. 4	7½	7½	Alliance & Dublin Ord. ...	101—106	...	105½—107½
374,000	,,	Jan. 4	4	4	Do. 4 p.c. Deb. ...	70—75	...	76½—77
557,655	,,	Mar. 14	7	7	Barnet Ord. 7 p.c.	127—132	...	...
300,000	1	Apl. 29	1/4½	1/9½	Bombay, Ltd.	15/—20/-	...	17/9—18/-
177,750	10	Feb. 29	9	9	Bournemouth 5 p.c. ...	16½—17½	...	17½
500,050	10	,,	7	7	Do. B 7 p.c. ...	13—14	+¼	13⅜—13⅝
439,160	10	,,	6	6	Do. Pref. 6 p.c. ...	11½—12½	...	...
50,000	Stk.	Dec. 14	3	3	Do. 3 p.c. Deb. ...	62—67	...	...
162,025	,,	,,	4	4	Do. 4 p.c. Deb. ...	83—88	...	...
210,000	,,	,,	5	5	Do. 5 p.c. Deb. ...	105—108	...	...
					Brighton, Hove, & Worthing 6 p.c. Con. ...	122—127	...	126—126½
357,900	,,	Mar. 14	7½	7½	Do. 5 p.c. Con. ...	109—114	...	112½—113
540,000	,,	,,	6½	6½	Do. 6 p.c. B Pref.	115—120	+1	117—119½
195,500	,,	,,	6	6	Bristol 5 p.c. max.	98—100a	...	...
1,287,500	,,	Feb. 29	5	5	Do. 1st 4 p.c. Deb. ...	86—87a	...	...
120,420	,,	Jan. 4	4	4	Do. 2nd 4 p.c. Deb. ...	85—87a	...	...
217,870	,,	,,	4	4	Do. 5 p.c. Deb.	100—102a	...	...
328,790	,,	,,	5	5	British Ord.	113—118	...	117½—117½
855,000	,,	Apl. 4	7	8	Do. 7 p.c. Pref. ...	115—120	...	...
100,000	,,	Jan. 4	7	7	Do. 4 p.c. Red. Deb. ...	77—82	...	...
120,000	,,	,,	4	4	Do. 5 p.c. Red. Deb.	98—103	...	...
450,000	,,	,,	5	5	Cambridge 5 p.c. Deb. ...	100—105	...	...
160,000	,,	Jan. 4	5	5	Cape Town, Ltd.	7½—8½	...	...
100,000	10	May 23	6	6	Do. 4½ p.c. Pref. ...	6—7	...	...
100,000	10	Apl. 29	4½	4½	Do. 4½ p.c. Deb. ...	76—81	...	78½
150,000	Stk.	Jan. 4	4½	4½	Cardiff Con. Ord.	100—105	...	...
626,860	,,	Feb. 15	6	6	Do. 5 p.c. Red. Deb.	97—102	...	...
237,860	,,	Jan. 4	2½	5	Chester 5 p.c. Ord.	87—92b	...	...
157,150	,,	Feb. 15	5	6½	Colombo, Ltd. Ord.... ...	26/—31/-	...	...
98,936	1	May 23	2/-	2/-	Do. 7 p.c. Pref.	17/—19/-	...	...
24,500	1	,,	1/4½	1/4½	Colonial Gas Assn. Ltd. Ord.	10/—15/-	...	...
609,204	1	Apl. 4	-/10'90	-/11'47	Do. 8 p.c. Pref.	10/—15/-	...	...
296,053	1	,,	1/3'54	1/3'30	Commercial Ord.	96—99	...	...
2,078,280	Stk.	Feb. 15	6	5½	Do. 3 p.c. Deb. ...	61—64	...	...
475,000	,,	Dec. 14	3	3	Croydon sliding scale ...	120—125	+2	120½—123
807,560	,,	Feb. 15	7	7	Do. max. div.	82—87	...	86
469,590	,,	,,	5	5	Do. 5 p.c. Deb.	102—107	—	106
500,000	,,	Jan. 4	5	5	Derby Con.	117—122c	...	...
542,270	,,	Feb. 29	7	10	Do. 4 p.c. Deb.	66—70c	...	...
55,000	,,	Jan. 4	4	4	East Hull Ord. 5 p.c. ...	75—80	...	...
209,000	,,	Mar. 14	5	5	East Surrey Ord. 5 p.c. ...	93—98	...	97½
179,500	,,	Feb. 29	5½	5½	Do. 5 p.c. Deb. ...	100—105	+3	...
155,019	,,	Jan. 4	5	5	European, Ltd.	80—90	−5	84—90
1,002,180	,,	Mar. 14	14	16½	Gas Light & Coke 4 p.c. Ord.	20/6—21/6f	...	20/10½—21/6
19,405,992	,,	Feb. 15	5½	5½	Do. 3½ p.c. max. ...	66—70	+1	67—68½
2,600,000	,,	,,	3½	3½	Do. 4 p.c. Con. Pref. ...	84—88	+1	86—87½
4,477,106	,,	,,	4	4	Do. 3 p.c. Con. Deb. ...	66—70	+½	68½—70
6,102,497	,,	Dec. 14	3	3	Do. 5 p.c. Red. Deb. ...	104—107	...	106½—107
3,442,770	,,	,,	5	5	Do. 4½ p.c. Red. Deb. ...	101—104	...	102½—104
2,500,000	,,	,,	4½	4½	Harrogate New Cons. ...	97—102	...	100⅞—101⅝
264,011	,,	—	—	—	Hastings & St. L. 5 p.c. Conv.	103—108	...	...
82,500	,,	Mar. 14	7	7	Do. 3½ p.c. Conv.	82—87	...	...
258,740	,,	,,	5½	5½	Hongkong & China, Ltd. ...	10—11*	−1	...
70,000	10	June 6	15	10	Hornsey Con. 3½ p.c. ...	95—100	+9	...
213,200	Stk.	Feb. 29	6	6	Imperial Continental Cap.	143—153†	−7	144—152
5,600,000	,,	Oct. 30	25	15	Do. 3½ p.c. Red. Deb.	72—77	...	...
223,190	,,	Feb. 1	3½	3½	Ipswich 5 p.c. Ord. ...	134—139	...	138
235,242	,,	Mar. 14	5½	5½	Liverpool 5 p.c. Ord. ...	106—107b	...	...
2,145,907	,,	Feb. 29	6	6	Do. 5 p.c. Red. Pref. ...	97—102b	...	...
245,500	,,	—	—	5	Do. 4 p.c. Deb.	85—90b	...	...
306,083	,,	Jan. 15	4	4	Maidstone 5 p.c. Cap. ...	124—129	...	...
165,786	,,	Feb. 15	8	10	Do. 3 p.c. Deb. ...	57—62	...	...
58,176	,,	Jan. 4	3	3	Malta & Mediterranean ...	7—8	...	...
76,000	5	Nov. 30	110	110	Metropolitan (of Melbourne) 5½ p.c. Red. Deb. ...	80—85	...	...
892,000	—	Apl. 1	5½	5½	M. S. D. Utility "C." Cons.	76—81	...	...
171,978	Stk.	Feb. 29	5	5	Do. 4 p.c. Cons. Pref.	77—82	+1	...
718,657	,,	,,	4	4	Do. 4 p.c. Deb. ...	78—83	...	...
142,126	,,	£	4	4	Do. 5 p.c. Deb. ...	100—105	...	...
148,955	,,	£	5	5	Montevideo, Ltd.	50—70	...	...
675,000	,,	21 May '31	16	16	Newcastle & Gateshead Con.	18/6—19/6d/	—/3	...
2,061,315	,,	Feb. 29	5	5½	Do. 4 p.c. Pref. ...	79—81d	+1	...
682,856	,,	,,	4	4	Do. 3½ p.c. Deb. ...	74—76d	...	...
691,705	,,	Jan. 4	3½	3½	Do. 5 p.c. Deb. '43...	99—101d	...	...
277,285	,,	Oct. 30	5	5	North Middlesex 6 p.c. Con.	118—123	...	...
199,940	,,	Mar. 14	7½	7½	Northampton 5 p.c. max. ...	82—87	+4	...
396,160	,,	Feb. 15	5	5	Oriental, Ltd.	85—95	...	...
300,000	,,	Apl. 18	9	7	Plym'th & Stonehouse 5 p.c.	127—132	...	129
205,162	,,	Jan. 4	8	8	Portsm'th Con. Stk. 4 p.c. Std.	126—131	...	128½—130
504,416	,,	Feb. 15	8	8	Do. 5 p.c. max. ...	78—83	...	80—82
241,446	,,	,,	5	5	Preston 5 p.c. Pref.	94—99	...	...
114,000	,,	Feb. 15	5	5	Primitiva 4 p.c. Rd. Db. 1911	77—82	...	...
686,312	,,	Jan. 18	4	4	Do. 4 p.c. Cons. Deb.	77—82	...	...
389,813	,,	Jan. 4	4	4	San Paulo 6 p.c. Pref. ...	7—7½	...	...
150,000	10	Apl. 4	6	6	Sheffield Cons.	101—103e	...	...
1,736,968	Stk.	Apl. 4	6	6	Do. 4 p.c. Deb. ...	81—84e	+2½	...
95,000	,,	Jan. 18	4	4	Shrewsbury 5 p.c. Ord. ...	99—104	...	...
133,201	,,	Feb. 29	5½	5	South African	3—5*	...	...
90,000	10	June 6	15	15	South Met. Ord.	105—108	+1	106—107¾
6,709,895	Stk.	Feb. 15	5	7	Do. 6 p.c. Irred. Pf.	115—120	...	119
1,185,812	,,	,,	6	6	Do. 3 p.c. Deb. ...	66—70	+1	68—70
1,895,445	,,	Jan. 4	3	3	Do. 5 p.c. Red. Deb.	102—105	...	...
1,000,000	,,	Jan. 18	4	5	South Shields Con.	129—131d	...	...
91,500	,,	Feb. 29	8½	8½	South Suburban Ord. 5 p.c.	102—107	...	106
1,543,795	,,	Feb. 15	6½	6	Do. 5 p.c. Pref.	97—102	...	...
300,000	,,	,,	5	5	Do. 5 p.c. Deb.	102—107	...	105½—106¾
668,837	,,	Jan. 4	5	5	Southampt'n Ord. 5 p.c. max.	79—84	...	...
647,740	,,	Feb. 29	5	5	Do. 4 p.c. Deb.	77—82	...	...
121,275	,,	,,	4	4	Swansea 7 p.c. Red. Pref. ...	98—102	...	...
250,000	,,	Aug. 24	7	7	Do. 6½ p.c. Red. Deb.	99—102	...	...
200,000	,,	Jan. 4	6½	6½	Tottenham and District Ord.	111—116	+3½	114½—115½
1,076,490	,,	Feb. 29	6½	6½	Do. 5½ p.c. Pref. ...	102—107	...	...
300,000	,,	,,	5½	5½	Do. 4 p.c. Deb. ...	80—85	+3	80
192,905	,,	Dec. 14	4	4	Tuscan, Ltd., 6 p.c. Red. Db.	70—75	...	...
85,701	,,	Apl. 4	6	6	Uxbridge, Maidenhead, & Wycombe 5 p.c.	108—113	...	...
346,069	,,	Feb. 29	7	7	Do. 5 p.c. Pref. ...	95—100	...	...
88,330	,,	,,	5	5	Wandsworth and District: Consolidated	120—125	...	122
1,323,220	,,	Feb. 29	7	7	Do. 5 p.c. Pref. ...	98—103	...	102½—102½
971,378	,,	,,	5	5	Do. 5 p.c. Deb.	104—107	+1	106½—106¾
1,167,964	,,	Jan. 4	5	5	Winchester W.&G.5p.c.Con.	85—90	...	...
158,400	,,	Feb. 29	5	6A				

Quotations at:—*a.*—Bristol. *b.*—Liverpool. *c.*—Nottingham. *d.*—Newcastle. *e.*—Sheffield. *f.*—The quotation is per £1 of stock. *g* The interest due 1/1/32 was paid on that date. A Paid £3, including 10s. on account of back dividends. * Ex. div. † Paid free of income-tax. ‡ For year.

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Applicants, who must be not more than 40 years of age, must be live energetic Salesmen, fully Trained and Experienced in the Sale of Gas and Appliances, and in all Modern Domestic and Industrial Applications of Gas.

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Commencing Salary, £350 per Annum.

The successful candidate will be required to pass a Medical Examination before taking up his duties.

Applications, endorsed "Sales," and accompanied by *copies* of Two recent Testimonials, should be received by the Chairman of the Company not later than Thursday, the 30th of June, 1932.

S. E. WHITEHEAD,
Engineer and General Manager.
Southampton Gaslight and Coke Company,
66, Above Bar,
Southampton.

WANTED—Secretary for Statutory Gas Undertaking in West of England, with an Annual Output of 80 Million Cubic Feet of Gas. Candidates should be experienced in such duties, and not above 35 years of age. Commencing Salary, £250 per Annum, with free Fuel and Light.

Applications, accompanied by *copies* of Three recent Testimonials, should be sent to No. 8230, "GAS JOURNAL," 11, BOLT COURT, FLEET STREET, E.C. 4, and reach there not later than the 23rd of June, 1932.

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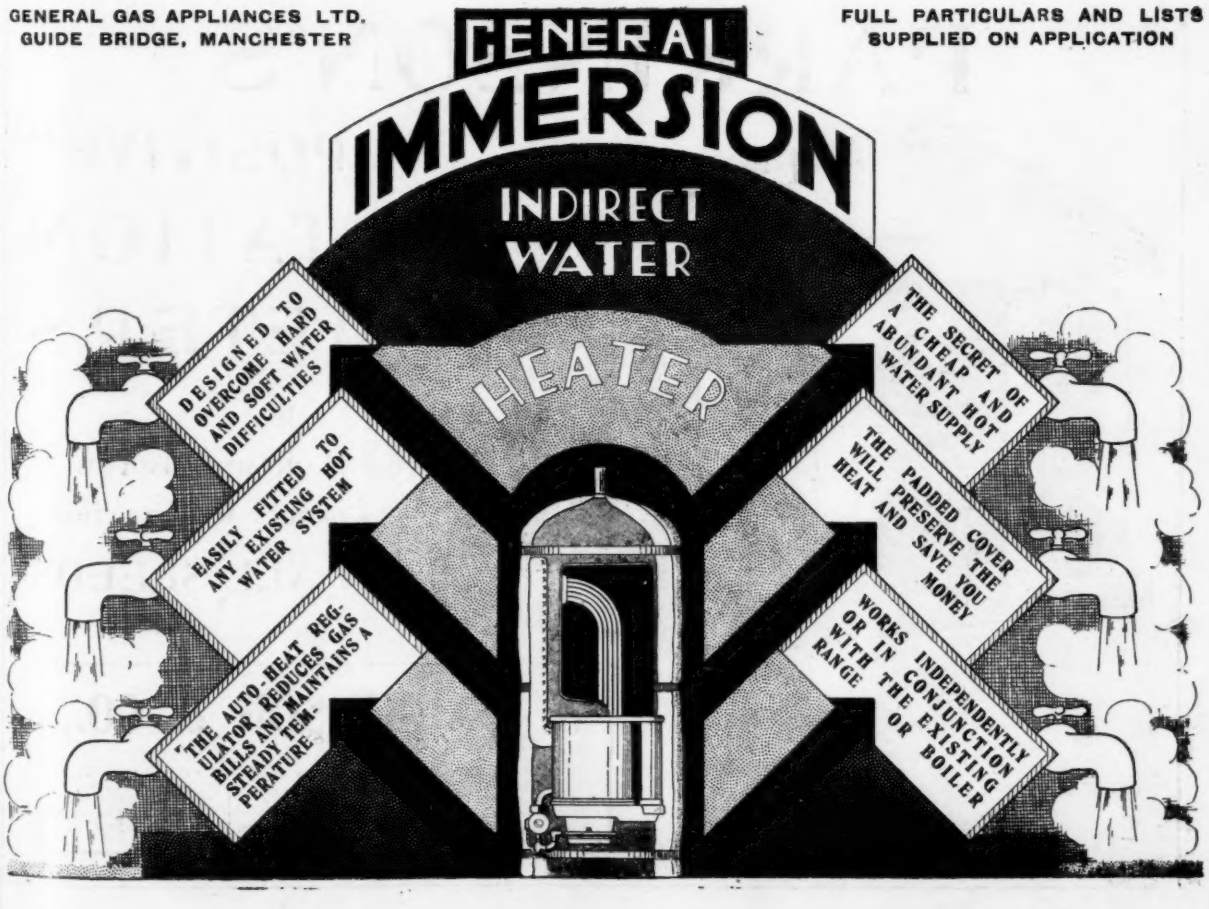
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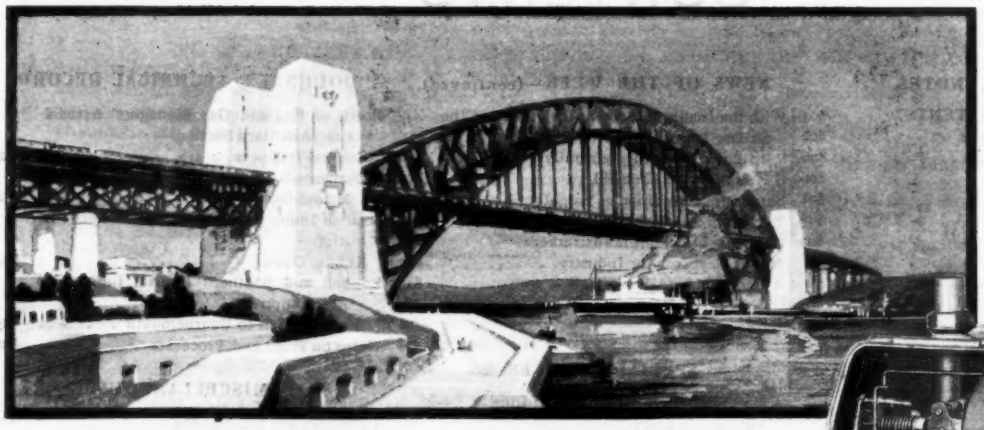

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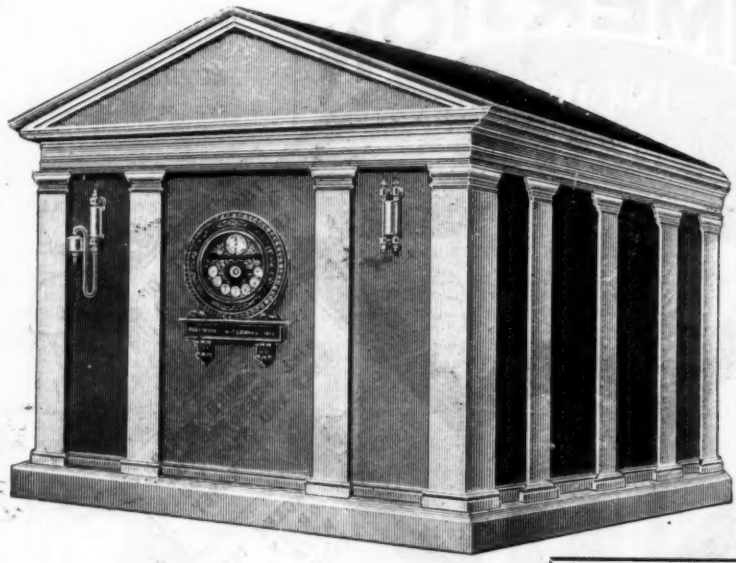

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